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LOYALTY TESTS FOR SCIENCE STUDENTS?

ON March 1 the House of Representatives passed a bill to establish a National Science Foundation (H.R. 4846). Immediately preceding its passage two amendments proposed by Representative Howard Smith and by Representative Daniel J. Flood had been passed by voice vote and written into the bill. These amendments required the FBI to investigate and *to approve* all employees and fellowship holders in the Foundation, and to investigate all aliens associated with the Foundation, regardless of whether or not they had been certified by their own governments. Many scientists feel that these amendments seriously weaken the purposes of the legislation and are making strenuous efforts to have them removed in the Senate-House conference on the bill. The objections to these amendments were clearly voiced by Dr. Hugh Wolfe, President of the Federation of American Scientists in the following statement:

DR. HUGH WOLFE'S STATEMENT

The police-state methods and ideas of Hitler and Stalin got a majority vote in the House on March 1. The House adopted an amendment to the National Science Foundation Bill, H.R. 4846, providing that all holders of fellowships and all others whose research work is to be supported by the Foundation must be *investigated* and *certified* by the FBI (This means that the FBI is to be detective, judge, and jury[1]) and must never at any time have been members of any organization on the Attorney General's list. I can see only three bases on which a Congressman could support this amendment, and they are: (1) failure to appreciate its significance, (2) a desire to kill the bill by making it so vicious that its proponents could no longer support it, (3) a genuine advocacy of the police-state idea.

The Federation of American Scientists concurs in the necessity of clearance procedures for that large group of its own members who are now working on atomic energy projects where they must have access to secret data. But such investigation is totally improper for men working on non-secret, non-military basic science which is the area of the National Science Foundation. I believe that our government is justified in spending federal funds on a National Science Foundation because basic science provides the foundation for the industrial and military technologies that make our country strong. But I could not support a bill containing this new amendment.

We are not asking any special dispensation for scientists. One argument advanced is that federal funds are being spent and that therefore these elaborate loyalty checks are justified even though the work is non-secret. The same argument would apply with equal logic to the farm price support program. Should every farmer who benefits be investigated by the FBI? Our postal system operates at a deficit so everyone who mails a letter is receiving federal aid. Should everyone who mails a letter be investigated and certified by the FBI? The pattern set forth in this vicious amendment belongs only to the totalitarian system where the secret police keep a dossier on every citizen.

The bill should be passed, but without this amendment. It should be stricken out in the House-Senate conference committee.

* * *

If the bill should be passed with its present amendments, scientists may decide to press for a Presidential veto. (The President has already vetoed an earlier version because of its unsatisfactory administrative structure.) And, if the bill becomes law, universities might well decide to refuse to make use of federal grants proffered under conditions so deeply and needlessly offensive to academic freedom.

[1] Spokesmen for the FBI have expressed their reluctance to accept this "un-American authority."

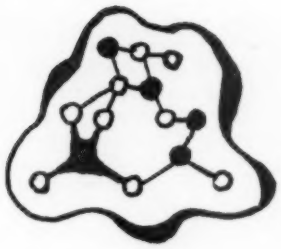
Loyalty Provisions in H.R. 4846

H.R. 4846. *Section* 10 *(b)* "No part of any funds appropriated or otherwise made available for expenditure by the Foundation under authority of this Act shall be used to make payments under any scholarship or fellowship to any individual unless there is on file with the Foundation an affidavit executed by such individual that he does not believe in, and is not a member of and does not support any organization that believes in or teaches, the overthrow of the United States Government by force or violence or by any illegal or unconstitutional methods. The provisions of section 1001 of title 18, United States Code, shall be applicable in respect of such affidavits."

Section 14 (1) [Amendment passed by voice vote Feb. 28, 1950, introduced by Rep. Howard W. Smith, Dem., Virginia] "No person shall be employed by the Foundation and no scholarship shall be awarded to any person by the Foundation unless and until the Federal Bureau of Investigation shall have investigated the loyalty of such person and reported to the Foundation such person is loyal to the United States, believes in our system of government, and is not and has not at any time been a member of any organization declared subversive by the Attorney General or any organization that teaches or advocates the overthrow of our Government by force and violence."

Section 14 *(m)* [Amendment passed March 1, 1950, introduced by Rep. Daniel J. Flood, Dem., Pa.] "No person a national of a foreign country shall be associated with the Foundation in any capacity whatsoever unless and until the Federal Bureau of Investigation, independent of any investigation made by the government of such person, shall have investigated such person and reported to the Foundation that such person is not and has not at any time been a member of any organization that teaches or advocates the overthrow of the Government of the United States by force and violence."

THE HYDROGEN BOMB



Hans A. Bethe

Hans Bethe, Professor of Physics at Cornell University, was formerly Director of Theoretical Physics at the Los Alamos Laboratories. Dr. Bethe is noted for his discovery of the thermonuclear origin of the sun's energy.

IN THIS article I shall discuss some of the scientific, moral, and political aspects of the hydrogen bomb.[1] On the technical side, I shall try to clarify the many misconceptions which have crept into the discussions in the daily press. On the political side, I wish to take up the moral issue and the meaning of the H-bomb in the general framework of our foreign relations.

IMPOSSIBILITY OF COMPLETE MASS-ENERGY CONVERSION

Everybody who talks about atomic energy knows Einstein's equation $E=mc^2$; thus the energy release in a nuclear reaction can be calculated from the decrease in mass. In the fission of the uranium nucleus, one-tenth of 1 per cent of the mass is converted into energy; in the fusion of four hydrogen nuclei to form helium, seven-tenths of 1 per cent. When these statements are made in newspaper reports, it is usually implied that there ought to be some way in which *all* the mass of a nucleus could be converted into energy, and that we are merely waiting for technical developments to make this practical. Needless to say, this is wrong. Physics is sufficiently developed to permit the statement that there will never be a way to make a proton or a neutron or any other nucleus simply disappear, its mass being converted into energy.

It may be objected that physics *does* know of processes in which particles simply disappear and their total mass is converted into energy. The oldest and most important example is the positive electron, discovered by Anderson in 1932, and now familiar in every physics laboratory: When this particle meets a negative electron (the particle found in every atom), it can happen that the two annihilate each other. The energy liberated is $2\ mc^2$, with m the mass of the electron (positive and negative electrons have the same mass), and this energy appears in the form of gamma radiation. This, however, is not a practical method to produce energy because the positive electron must first be created. This creation is the inverse of the annihilation process; a gamma ray of high energy E creates a *pair* of electrons, one positive and one negative; the energy $2\ mc^2$ is consumed in the creation of their mass, while the rest of the energy of the gamma ray is given to the electrons as kinetic energy.

Similar processes are the creation and annihilation of mesons, particles not normally found in nature in the free state. All these phenomena in which the entire mass of particles is transformed into energy, have *one* thing in common: they involve at least one particle which does not normally occur in nature and which must first be created, and this creation process consumes as much energy as is afterwards liberated. The very fact that energy is liberated when they disappear makes these particles, positron, meson, etc., unstable, so that they do not "live long" and thus have to be created each time before they can be observed. Physicists believe that there is also an "anti-proton" of negative electric charge which can be annihilated by combination with the ordinary proton, just as a positive and a negative electron. This particle has not yet been observed, but it can be predicted that it too has a short life, and that in its creation as much energy must be spent as will be liberated in its annihilation. The complete destruction of a particle is therefore not a feasible way to release energy, not even theoretically.

All the nuclear processes from which energy *can* be liberated, involve the *rearrangement* of protons and neutrons in nuclei, the protons and neutrons themselves remaining intact. Hundreds of experimental investigations have taught us, through the last thirty years, how much energy can be liberated in each transformation. Fission of heavy nuclei (splitting into two smaller ones) and fusion of light ones (combination of two or more nuclei to form a larger one) can release energy. Only the fusion of the very lightest nuclei, however, releases large amounts of energy. For example, in the fusion of four hydrogen nuclei to form helium, 0.7 per cent of the mass is transformed into energy, but when four helium nuclei are in turn fused into oxygen the mass decreases by only 0.1 per cent, and the fusion of two silicon atoms, if it ever could occur, would release less than 0.02 per cent of the mass. There is thus no prospect of using elements of medium atomic weight for the release of nuclear energy.

RATE OF REACTION

The main problem in the release of nuclear energy, however, is not the *amount* of energy available—there are plenty of nuclear reactions in which it is large enough—but whether there is a *mechanism* by which the release can proceed at a sufficient rate. This consideration is almost invariably ignored by science reporters who seem to be incurably fascinated by the equation $E=mc^2$. The rate of reaction is governed by entirely different factors in fission and fusion: Fis-

[1]Further scientific information is given in an article by Dr. Ridenour in the March issue of the *Scientific American* in which the effect of the bomb on the military situation is also evaluated. A portion of this article is reprinted on page 105 of this issue.

sion takes place when a nucleus of uranium or plutonium captures a *neutron*. The fission reaction will proceed as long as there are neutrons present, and it will proceed at an accelerated rate if the neutrons multiply, as they do in a lump of uranium which has more than the critical mass. The temperature has no important influence on the fission reaction; no matter how slow a neutron, it can enter a uranium nucleus and cause fission. This is because the neutron has no electric charge and is therefore not repelled by the nucleus.

In fusion reactions, on the other hand, two nuclei must come in contact, *both* of which have positive electric charges. For instance, in the "carbon cycle" which is mainly responsible for the energy of the stars, a proton must collide and react with a nucleus of carbon or nitrogen. Since both nuclei are positively charged, there are strong forces of electric repulsion between them. To overcome these, the nuclei must approach each other with great speed. In the laboratory this is achieved by giving very high velocities to a very few nuclei; this method is inefficient because it is unlikely that one of the fast "projectiles" will hit a target nucleus before it loses most of its energy to the electrons which also are present in the atoms of the target. Therefore, in this laboratory method, the energy released by nuclear reactions is always much less than the energy invested initially in accelerating the particles. This obviously makes the method impractical for the production of nuclear power.

The only known way in which energy can actually be extracted from light nuclei is by *thermo-nuclear reactions*, i.e., nuclear reactions which proceed at exceedingly high temperatures. The prime example of thermo-nuclear reactions are the processes in the interior of the stars, where temperatures are of the order of twenty million degrees centigrade. At this temperature, the average energy of an atom is still only 1,700 electron volts, much less than the energies given to nuclear particles in "atom smashers." But in the star, *all* atoms, nuclei, and electrons, have high kinetic energy, so that they are *not* slowed down by colliding with each other, in contrast to the projectiles in the "atom smashers." They will keep their high speeds "forever." In spite of the high temperature, the nuclear reactions in stars proceed at an extremely slow rate; only 1 per cent of the hydrogen in the sun is transformed into helium in a billion years. Indeed it would be catastrophic for the star if the reaction went much faster.

The temperature at the center of a star is kept high and very nearly constant by an interplay of a number of physical forces. The main point is that the radiation which is produced in the nuclear reactions can escape from the star only with great difficulty. A quantum of radiation which is emitted by one atom will be absorbed by another atom before it has gone one-tenth of an inch; in other words, stellar matter is very "opaque." The absorption of the quantum increases the energy of the second atom, which after a while emits a new quantum. The latter travels in a random direction unrelated to that of the old quantum. Thus, light does not proceed from the interior of the star to the surface in a straight line (which would take about three seconds) but in an extremely complicated zigzag path, by "diffusion." It can be calculated that in our sun the escape of radiation from the center takes about 10,000 years. A corollary of this slow diffusion of radiation is that the temperature at the surface of the star is much lower than in the interior; for the sun, these temperatures are 6,000 and 17,500,000 degrees, respectively. This keeps the emission of radiation from the surface moderate and prevents the cooling of the interior. Conditions in the star adjust themselves in such a way that the energy production in the center exactly corresponds to the loss of radiation from the surface: Any deviation which might occur is quickly eliminated; the star is an excellent thermostat.

Only the very large size of stars makes it possible to maintain permanently in their interior temperatures which make significant energy production by nuclear reactions possible. A star weighing one-tenth as much as the sun would produce so little energy that it would not be visible (some such stars have been detected by the infra-red radiation they emit). The largest planet in the solar system, Jupiter, is so small that it could not maintain nuclear reactions; and the earth, of course, is smaller still. This rules out the possibility that the earth's atmosphere, or the ocean, or the earth's crust, could be set on fire by a hydrogen bomb, and the earth converted into a star. Because of the small mass, radiation would carry away the nuclear energy much faster than it is developed, and the temperature would drop rapidly so that the nuclear reaction would soon stop.

THE MATERIALS FOR THERMO-NUCLEAR REACTIONS

If thermo-nuclear reactions are to be initiated on earth, one must take into consideration that any nuclear energy which may be released will be carried away rapidly by radiation so that it will not be possible to keep the temperature high for a long time. Therefore, if the reaction is to occur at all, it must occur very quickly. Reaction times of billions of years, like those in the sun, would never lead to an appreciable energy release on earth; we must rather think in millionths of a second. On the other hand, while the stellar reactions can only use the elements which happen to be abundant in stars, notably ordinary hydrogen, we can choose any element we like for our thermo-nuclear reactions. We shall obviously choose those with the highest reaction rates.

The reaction rate depends first of all, and extremely sensitively, on the product of the electric charges of the reacting nuclei. The highest rates will, therefore, be obtainable from a reaction between two hydrogen nuclei because hydrogen has the smallest possible charge, one elementary unit. (The principal reactions in stars are between carbon, of charge six, and hydrogen.) Next, we can choose any of the three isotopic hydrogen nuclei, of atomic weight 1 (proton), 2 (deuteron), or 3 (triton). This choice is again easily made because these isotopes undergo different *types* of nuclear reactions. A fusion of two protons—the *pp* reaction—has long been known to proceed exceedingly slowly; a proton lives an average of 100 billion years at the center of the sun until it disappears by this reaction. As pointed out in Ridenour's article, the situation is quite different for the reactions between the heavy forms of the hydrogen nucleus, called the deuteron and the triton. Measurements have shown that for this type of fusion the reaction rates are quite high. (See p. 105 of this issue.)

CONDITIONS NECESSARY FOR THE REACTION

A further variable governing the rate of thermo-nuclear reactions is density. The more atoms there are per unit volume, the greater the chance for a nuclear collision. Whether the tem-

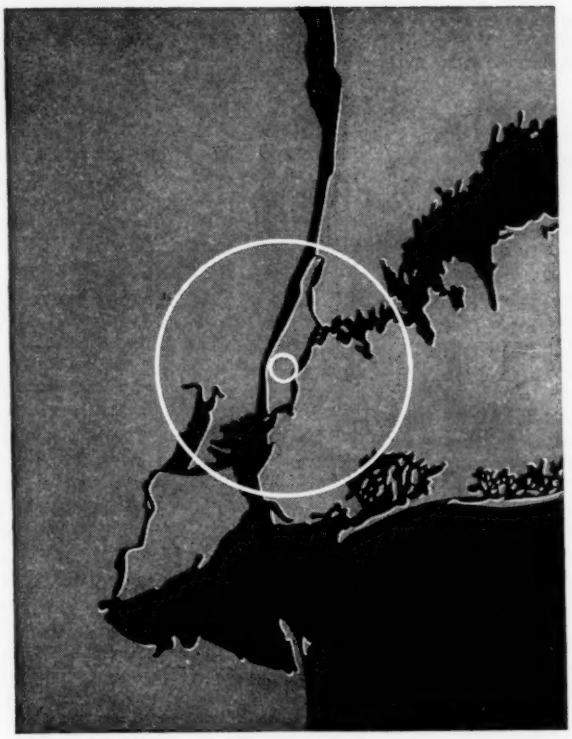


Fig. 1

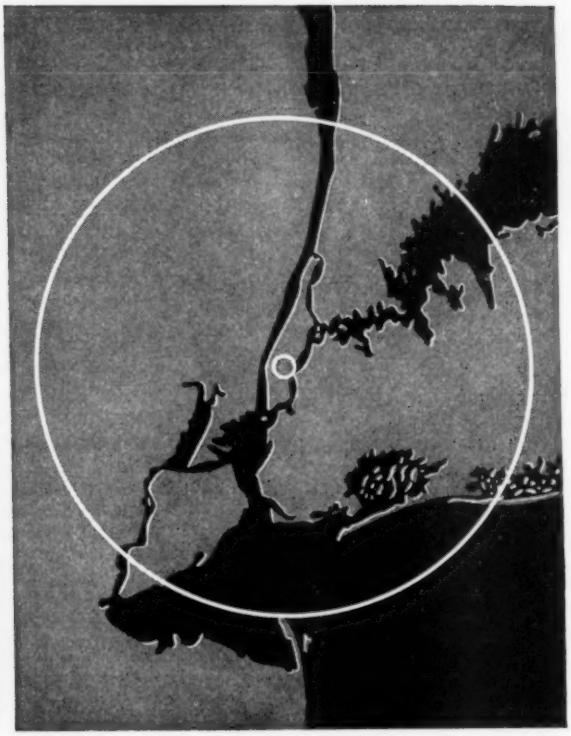


Fig. 2

EFFECTS OF present uranium bomb (small circle, each map) and proposed hydrogen bomb, 1,000 times more powerful (large circle) on New York and surrounding area. Figure 1 shows areas of severe destruction by blast; Figure 2, areas within which flash burns would be lethal.*

peratures required to start a thermonuclear reaction between heavy hydrogen nuclei, even under the most favorable practical conditions, can be achieved on earth is a major problem in the development of the fusion bomb. To find a practical way of detonating such bombs will require much research and considerable time.

EFFECTS OF HYDROGEN BOMB

What would be the effects of a hydrogen bomb? Its power would be essentially unlimited and would increase as the amount of heavy hydrogen that can be carried in the bomb. For instance, if the bomb is carried by a submarine it might be much larger and therefore more powerful than if carried by a plane. For the sake of argument, however, we shall assume an energy release a thousand times greater than the Hiroshima bomb. The radius of severe destruction by blast at Hiroshima was a mile, and this radius will increase as the cube root of the power; an H-bomb will therefore cause almost complete destruction of buildings up to a radius of ten miles. A single bomb can obliterate almost all of greater New York or Moscow or London, or any of the largest cities of the world. (See Figure 1.)

About 30 per cent of the casualties in Hiroshima were caused by the flash —the intense burst of heat radiation from the bomb—fatal burns being frequent up to distances of 4,000 or 5,000 feet. The radius of heat radiation would increase even more than that of blast, namely by the square root of the power, or by a factor of thirty. This would make flash burn from an H-bomb lethal up to 20 miles or more. Numbers are too easily written down and read; one must visualize what it would mean if Chicago, for instance, with all its suburbs and most of their inhabitants were wiped out in a single flash. (Figure 2 shows area of flash effects on New York and surrounding area.)

RADIOACTIVITY

In addition to blast and heat radiation there are nuclear radiations. Some of these are instantaneous; they are emitted by the exploding bomb itself and may be absorbed by the bodies of persons in the bombed area. Others are delayed; these come from the radioactive nuclei formed as a consequence of the nuclear explosion, and they may be confined to the explosion area or widely distributed.

The bombs, both A and H, emit gamma rays and neutrons while they explode. Either of these radiations can enter the body and cause death or radiation sickness. All nuclear radiation casualties in Hiroshima and Nagasaki were due to this instantaneous nuclear radiation. However, the range over which the neutrons (and gamma rays) have a lethal effect will not be much greater than for the A-bomb, in spite of their much greater number. It is therefore likely that most of the people who would get a lethal dose of radiation would be killed in any case by flash burn or by collapsing or burning buildings. If tritium is used, neutrons of high energy (14 Mev) are emitted which travel farther than deuterium neutrons (3 Mev), but the main conclusion is not changed.

* The author is not responsible for the illustrations which have been compiled by the editors of *Scientific American* on the basis of previously published material.

The persistent radioactivity formed is of two kinds, the fission products formed in the bomb itself, and the radioactive nuclei formed by the neutrons which are emitted by the bomb. Since the H-bomb must be initiated by an A-bomb it will produce at least as many fission products as the latter. Like the A-bomb, the H-bomb can be exploded high up, in which case there will be little radioactive contamination of the bombed area, or it may be detonated on the ground in which case there will be much.

The main increase in radioactive effect is due to the neutrons which are emitted by the H-bomb. They may be absorbed by the bomb case, by rocks and other matter on the ground in the bombed area, or by the air. In any case, radioactive nuclei will be formed. Those formed on the ground will contaminate the center of the bombed area for some time, but probably not very long because the constituents of soil and buildings do not form many long-lived radioactive nuclei by neutron capture. On the other hand, the bomb case could be so designed that it would become highly radioactive in the explosion in which it would at the same time disintegrate; the radioactive atoms would then be carried by the wind over a large area of the bombed country and might be very dangerous, especially if a very large bomb or several bombs are exploded. This danger has been described by Dr. Teller in an article in the *Bulletin*.[2]

If the neutrons go into the air, they are finally captured by nitrogen nuclei which are thereby transformed into the radioactive isotope carbon 14. This isotope has a very long half-life, namely, 5,800 years. However, just because of its long life, the radioactivity is weak, and even if many bombs are exploded, the carbon 14 is not likely to become dangerous.

THE MORAL ISSUES

The decision to proceed with the development of hydrogen bombs has been made. I believe that this decision settles only one question and raises a hundred in its place. What will the bomb do to our strategic position? Will it give us back the superiority in armament which we possessed before the Russians obtained the A-bomb? Will it improve our chances of winning the next war if it comes? Will it diminish the likelihood of seeing our cities destroyed in that war? Will it serve to avert or postpone war itself? How will the world look after a war fought with hydrogen bombs?

I believe the most important question is the moral one: Can we, who have always insisted on morality and human decency between nations as well as inside our own country, introduce this weapon of total annihilation into the world? The usual argument, heard in the frantic week before the President's decision and frequently since, is that we are fighting against a country which denies all the human values we cherish, and that any weapon, however terrible, must be used to prevent that country and its creed from dominating the world. It is argued that it would be better for us to lose our lives than our liberty; and this I personally agree with. But I believe that this is not the question; I believe that we would lose far more than our lives in a war fought with hydrogen bombs, that we would in fact lose all our liberties and human values at the same time, and so thoroughly that we would not recover them for an unforeseeably long time.

Whoever wishes to use the hydrogen bomb in our conflict with Russia, either as a threat or in actual warfare, is adhering to the old fallacy that the ends justify the means. The fallacy is the more obvious because our conflict with Russia is mainly about means. It is the *means* that Russia is using, both in dealing with her own citizens and with other nations, that we abhor; with their professed aim of providing a decent standard of living for all, we have little quarrel. Therefore I believe we would invalidate our cause if we were to use in our fight, means that can only be termed mass slaughter.

What do we stand for in our conflict with Russia? We believe in personal liberty and human dignity, the value and importance of the individual, sincerity and openness in the dealings between men and between nations, prosperity for all, and peace based on mutual trust. Many of these values are denied and suppressed by the dictatorship of the Kremlin, and others, as far as we can see, are given only lip service.

However, the defenders of Russia will protest that all this is done to bring the Golden Age of Socialism to the world, to give every worker, and indeed every citizen, his fair share in the national product. This is an aim which seems worthy enough. We would probably argue that Marx's thesis that capitalism did not give a fair share to the workers may have been right a hundred years ago but has ceased to be so, that in fact Capitalist America comes very close to the ideal of the fair share to everyone, much closer probably than Communist Russia. We might also argue that private enterprise will ensure a larger share to everyone than government enterprise, and we do argue this point in all friendship with Socialist Britain.

But all this is not the main point of our conflict with Russia: What we deeply disagree with are the *methods* which the Russian Government uses in pursuing its aims and which it believes to be necessary in the "initial phase" of communism which by now has lasted thirty-three years. The regimentation of the private lives of all citizens, the systematic education toward spying upon one's friends, the ruthless shifting of populations, regardless of their personal ties and preferences, the labor camps with their inhuman treatment, the suppression of free speech, the falsification of history in dealing both with its own citizens and with other nations, the violation of promises and treaties and the distorted interpretations of these violations which are offered in excuse—these are some of the Soviet methods which are hateful to the people of the Western World. But they are methods, not aims, and if we wish to fight against them, our methods must be clean.

We believe in peace based on mutual trust. Shall we achieve it by using hydrogen bombs? Shall we convince the Russians of the value of the individual by killing millions of them? If we fight a war and win it with H-bombs, what history will remember is *not* the ideals we were fighting for but the method we used to accomplish them. These methods will be compared to the warfare of Genghis Khan who ruthlessly killed every last inhabitant of Persia.

Originally, the American method of waging war was aimed at saving lives as much as possible. The First World War, especially in its first years, had been a frightening example of the needless sacrifice of hundreds of thousands of soldiers in fruitless frontal attack. All the warring nations in the Second World War, and the American High Command particularly, were determined not to repeat this slaughter. So we substituted the war by machines for the war by soldiers wherever possible, and the war against production for the war at the battle front. But with the advent of the atomic bomb, and especially the hydrogen bomb, mechani-

[2]Edward Teller, "How Dangerous Are Atomic Weapons?" *Bulletin*, III (February 1947), 35-36.

cal warfare has defeated itself. Instead of saving lives, it takes more lives; instead of one soldier, it kills a hundred civilians. It is time to reconsider our real intentions.

THE RESULTS OF WAR WITH HYDROGEN BOMBS

What would an all-out war fought with hydrogen bombs mean? It would mean the obliteration of all large cities, and probably of many smaller ones. It would mean the killing of most of the inhabitants of the cities by direct action of the bombs, and possibly of many more people by radioactivity. Many of the survivors would perish for lack of shelter, others from hunger. The devastation that we have seen in Germany, and which overwhelmed many American visitors when they first saw it, would be nothing compared with the effects of hydrogen war.

After such a war, nothing would remain that resembles present civilization. The fight for mere survival would dominate everything. The destruction of the cities might set technology back a hundred years or more, and in the struggle for the bare necessities of life it would be difficult to rebuild any considerable number of factories. In a generation, even the knowledge of technology and science might disappear because there would be no opportunity to practice them. Indeed it is likely that technology and science would be suspected as works of the devil, having brought such utter misery upon man, and that a new Dark Age would begin on earth.

Theoretically, technology, factories, worldly goods are nothing to the moralist, even less than his life. But we know what physical destruction does to the moral values of a people. We have seen how many Germans, already demoralized by the Nazis, lost all sense of morality when during and after the war the bare necessities of life, food, clothing, and shelter were lacking. Democracy, human decency were empty words: There was no reserve strength left for such luxuries. If we have learned any lesson from the aftermath of World War II, it is that physical destruction brings moral destruction.

We have learned that prosperity is the best shield against communism and dictatorship, and in this knowledge we have poured billions into Western Europe to restore her economy. This generosity has won us more friends than anything else we did. But after the next war, if it were fought with atomic and hydrogen bombs, our own country would be as grievously destroyed as Europe and Russia, and we could no longer afford this generosity. It would be every one for himself, and every one against the other. If we had any intention of preventing renewed attacks upon ourselves, we could do so only by brute force, the very thing we are fighting against.

In all this, I have assumed that we would win this next war. What if we don't? In a Soviet-dominated world, our only hope would be that we could resist the occupation spiritually, and that thereby the ethical standards we believe in would be gradually reestablished. How can we expect to have this moral strength if we already regard moral considerations as secondary?

Why present all these arguments against H-bombs, and not against atomic bombs in general? Is there so much difference? Is an atomic bomb moral and a hydrogen bomb immoral, and if so, where does the distinction begin? I believe there was a deep feeling in this country that the use of atomic bombs on Japan had been a mistake, and that these bombs should be eliminated from national armaments. This feeling, indeed, was one of the prime causes of President Truman's offer of international control in 1945. We know that the negotiations for control have not led to success as yet. But our inability to eliminate atomic bombs is no reason to introduce a bomb which is a thousand times worse.

When atomic bombs were first introduced, there was a general feeling that they represented something new, that the thousandfold increase of destructive power from block-buster to atom bomb required and made possible a new approach. The step from atomic to hydrogen bombs is just as great again, so we have again an equally strong reason to seek a new approach. We have to think how we can save humanity from this last disaster. And we have to break the habit which seems to have taken hold of this nation, of considering every weapon as just another piece of machinery, and as fair means to win our struggle against Soviet Russia.

DOUBTFUL MILITARY VALUE OF H-BOMBS

We have talked about the moral issues which should prevent us from using hydrogen bombs as if we were sure that we alone would have them, and sure that they would contribute to our victory. The situation is rather the opposite. We can hardly expect to have a monopoly on hydrogen bombs. If we ever had any illusions on this, the events of the last months should have destroyed them. Russia has the atomic bomb. She has undoubtedly been helped in her efforts by the secret information she received from Dr. Fuchs, which presumably included many of the vital "secrets" of our project. But knowing how another group of scientists has put together the bomb does not by itself make a bomb: The prime requirements for this still are a group of highly capable scientists, a country determined to make this weapon, and a great industrial effort. We know now, if we ever doubted it, that Russia has all of these. If Fuchs had given his information to Spain, for instance, it would hardly have been understood, it would presumably not have been used and, even if used, it would almost certainly not have led to success. For the Russian scientists, on the other hand, the information must have resolved many doubts as to which steps to take next in their technical development, and it must have saved them a lot of costly and futile parallel developments.

Their obvious competence will presumably again bring success to the Russians when they try to develop the H-bomb. However, it would be wrong for us to believe, as we often seem to, that their decisions and their successes are independent of our own. Our decision to make the H-bomb indicated that we consider this project feasible and may well have caused them to make the same decision. This is the reason why I think our decision should have been made in secret if at all; but this became impossible when the advocates of the H-bomb used public statements as a means of exerting pressure on the President. If the Russians were already working on the H-bomb before our decision they will now have increased their effort.

Who will have the hydrogen bomb first, nobody can predict. We like to

assume that we shall be first. If so, I still refuse to believe that the United States, through possession of this weapon, would start a "preventive" war. This would violate all the fundamental beliefs of this nation, and that these beliefs are still strong is shown by the history of the past four years: we did not start a war although we had the monopoly of the atomic bomb. Clearly, then, the time will come when both Russia and this country have H-bombs. Then this country will be much more vulnerable than Russia: We have many more large cities, which would be inviting targets, and many of these lie near the sea so that they need not be bombed by plane but could be reached by submarine and perhaps a relatively short-range rocket. I think it is therefore correct to say that the existence of the hydrogen bomb will give us military weakness rather than strength.

But what, say the advocates of the bomb, if the Russians obtain the H-bomb first? Would this not create a peril to our nation against which we must guard by speedy development? If the Russians have the bomb, Dr. Urey argued in a speech just before the President's decision, they may confront us with an ultimatum to surrender. I don't believe we would accept such an ultimatum even if we did not have the H-bomb, nor that we would need to. I do not think that the hydrogen bomb is going to win a war in one stroke. True, our cities may be devastated in the first days of the war, and this would cripple our ability to conduct a long war with all modern weapons. But it would not seriously affect our power for immediate retaliation. Our atomic bombs, whether "old style" or hydrogen, and our planes will presumably be so distributed that they cannot all be wiped out at the same time, and would hence still be ready to take off and reduce the country of the aggressor to at least the same state as our own. The large bomb will bring untold destruction but no military decision.

I believe that "old fashioned" A-bombs would be sufficient to "even the score" in case of an initial Russian attack with H-bombs on this country. In fact, because of the greater number available, A-bombs may well be more effective in destroying legitimate military targets including production centers, and thus to equalize once more the military potential of the two countries. H-bombs, after all, are only "useful" against the largest targets of which there are very few in Russia. But suppose one would want to be in a position to retaliate with H-bombs as well, in case of a Russian attack: Then the reason why the United States is building them is to prevent the Russians from using them against us, if only for fear of our retaliation. And this reason, it seems to me, is the only one which has any validity at all.

STEPS TOWARD ATOMIC CONTROL

We have come to the conclusion that it is morally indefensible and militarily of very doubtful value to add the hydrogen bomb to our arsenal as simply another weapon. On the other hand, we found that our possession of these bombs might possibly put us into a better position if Russia, at some time in the future, should present us with an ultimatum based on her possession of this bomb. In that case, our development of the bomb would serve only the one purpose of providing the Russians with an added motive for not using the H-bomb against us. The only reason for our development of the bomb would then be to prevent its use, not to use it.

If this is our reason, we can contribute much to the peace of the world by stating this reason openly. This could, for instance, be done by a declaration, either by Congress or by the President, that the United States will never be the first to use the hydrogen bomb unless the bomb is used against us or one of our allies.

A solemn pledge of this kind was proposed in a press statement by twelve physicists, including myself, on February 4. It still appears to me as a practical step toward relief of the international tension, and toward "freedom from fear" for the world. The pledge would indicate our desire to avoid needless destruction, it would reduce the likelihood of the use of the hydrogen bomb in the case of actual war, and it would largely eliminate the danger that the H-bomb itself would precipitate a war. Such a danger always exists with any super weapon because each side may hope to gain an initial advantage by a surprise attack. We have shown that this advantage is probably illusory in the case of the hydrogen bomb. But still, the thought of the initial advantage persists, and in order to be sure to have the initiative, the military may decide to take action at a time when war could otherwise still be averted.

If we do not make this pledge, the hydrogen bomb would almost surely be used. Indeed, once war breaks out, our military leaders would be blamed if they did not start it with a full-scale hydrogen bomb attack. If the pledge is made, they would be blamed if they did so. When war breaks out, actions are largely automatic; the time for sober and constructive thought, even about war plans, is in peacetime.

If we were to use hydrogen bombs first, we would have to expect immediate retaliation, and the destruction of our great cities would be a certainty. If we do not use them, we can, of course, not be sure that we will save our cities. The pledge may not be relied on by our adversaries, but at least it would throw a certain amount of doubt into their minds and they might decide to wait and see. Perhaps they would not wish to provoke the certain use of the bomb by throwing the first one. Moreover, if they started a war, they would probably hope to capture our country intact, as far as possible, and to exploit its wealth rather than to conquer a heap of rubble.

We have proposed unilateral action, rather than an international treaty on this pledge. We have done this because negotiations with Russia are known to be long and frustrating, and international action without Russia would be meaningless. The pledge, on the other hand, would involve only this country, it could be made quickly, and it could not again lead to the disappointment of a breakdown of negotiations. On the other hand, we certainly would not want to exclude a pact with Russia on this subject: This might be the first point on which the two countries could agree, and this in itself would be important.

For, obviously, the pledge can only be a first step. What we really want is a workable agreement on atomic energy, as part of our efforts toward a lasting peace. Much has been said in the last few weeks about new negotiations on atomic control. Opinions vary from that of Senator McMahon who proposed to spend 50 billion dollars for rehabilitation of war devastated countries including Russia in exchange for an atomic settlement, to that of Senator Tydings who declared that an atomic settlement would now be unacceptable to this country unless it were coupled with general disarmament which he has advocated for a long time. Both of these viewpoints, and those of many other Senators, show the desire of this country for some agreement. At the same time there are persistent reports from the *New York Times* correspondent in Moscow that the Russians might like to negotiate. It seems to me that too

(Continued on page 125)

THE PHYSICS OF THE H-BOMB

Louis Ridenour

Mr. Bethe's article makes frequent references to an article by Mr. Ridenour, published in the March issue of "Scientific American." With the permission of the editors, we reprint here the section of Mr. Ridenour's article dealing with the basic physics of the hydrogen bomb.

THE fusion reactions that are likely to be most effective for producing energy are those that will go best at relatively low collision energies, since even the highest temperatures reached in the explosion of an atomic bomb correspond to rather modest bombarding energies from the laboratory standpoint. For this reason, the stellar-energy reaction cycle is out of the question; this cycle involves the fusion of hydrogen with heavy atoms such as carbon and nitrogen, and therefore proceeds relatively slowly even at temperatures of millions of degrees. It has been known for some time, however, that fusion reactions between the rarer, heavier isotopes of hydrogen can take place much more rapidly at substantially lower temperatures.

A few years ago the reaction that would have been chosen as the most promising for a hydrogen bomb was the fusion of two atoms of deuterium, or hydrogen of mass 2, containing one proton and one neutron. This results in the formation of helium 3, with the emission of a neutron and the release of about four million electron volts of energy.

$$H^2 + H^2 \rightarrow He^3 + n + 4 \text{ mev.}$$

Gamow has calculated the thermo-nuclear energy release from this reaction: the results were given in his 1946 book, *Atomic Energy*. He remarked that if the reaction took place of a temperature of something over one million degrees C., "a small charge of deuterium could be used as an explosive with tremendous destructive power."

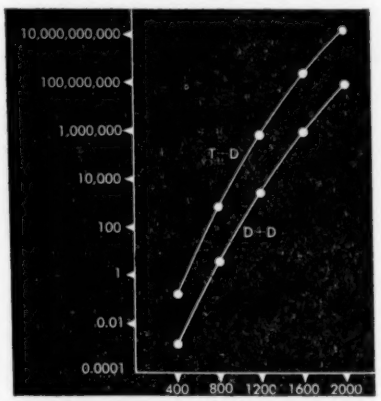
Nowadays we know that a more effective reaction can be obtained with hydrogen 3, known as tritium, a radioactive but long-lived isotope of hydrogen that has one proton and two neutrons in its nucleus. Tritium not only reacts faster than deuterium at low temperatures, but also liberates more energy when it does so. A fusion reaction of tritium with deuterium produces helium 4, with the emission of a neutron; its energy yield is 17.6 million electron volts. Tritium can also fuse with tritium, yielding helium 4, two neutrons and 11.4 million electron volts of energy; the cross-section for this reaction is not available in the published literature, but it is probably large.

$$H^3 + H^2 \rightarrow He^4 + n + 17.6 \text{ mev.}$$

$$H^3 + H^3 \rightarrow He^4 + 2n + 11.4 \text{ mev.}$$

Ponderable amounts of tritium have been and are being made by the Atomic Energy Commission in its huge facilities. The designer of a fusion bomb clearly would start with a fission bomb of uranium or plutonium, the explosion of which would produce the high temperatures required for the thermo-nuclear fusion reaction. To the fission bomb he would add a certain mixture of deuterium and tritium to fuel the fusion process. The final energy release of the bomb—its total deadliness—would be determined by the amount of deuterium added. To say the fusion bomb would be 2, 7, 10, 100, or 1,000 times as devastating as the conventional fission bomb is to speak from ignorance; the effective size of a fusion bomb will depend upon the intentions and the skill of its designers.

Note, however, that there is here no concept like that of critical size. The size of the bomb depends, and depends exactly, on the amount of the reacting elements built into it. The fission detonater itself must be made overcritical in order to explode, but the happenings thereafter will depend on the amount of fuel provided for the fusion reaction.



ENERGY RELEASED by the fusion of deuterium with deuterium (bottom curve) and tritium with deuterium (top curve) is plotted against temperature. The vertical coordinate is energy in calories per second per gram. The horizontal coordinate is thousands of degrees Centigrade. The figure is for density one (one gram in one cubic centimeter).

The Dangers of Declassification, 1651

Extract from a letter received by Johann Rudolf Glauber and quoted by him in his Prosperitate Germaniae, *Amsterdam, 1651; from the English translation by Christopher Packe, London, 1689, page 421.*

"Thou has written too clearly, and again too manifestly; beware lest God stir not up against thee another new Farnerian Devil, to punish thy easiness (or forwardness) of publishing such mysteries.* . . . For all wicked Men are not blind, I know many Farners that are defiled with all kinds of Evil, and yet not all of them so blinded as thy Farner is. Nay, Their wit is so penetrative and so clear-sighted, that should they but read the divine Books that thou has published there would not be a secret in all nature, but they would know it; nay more, they would in a short time perfect that Philosophick work. Which, should it come to pass, (the more's the grief) what a many Slaughtors, what Whoredoms, how many ruinings! And what evil of all sorts would break in upon mankind; of the which, thou thyself (though innocent) wouldst be the cause."

* Christopher Farner was an unscrupulous acquaintance of Glauber, who misappropriated and offered for sale many of Glauber's metallurgical and chemical "secrets."

THE FACTS ABOUT THE HYDROGEN BOMB

Hans Bethe, Harrison Brown,
Frederick Seitz, Leo Szilard

On February 26 four scientists expressed their views on the hydrogen bomb on the University of Chicago Round Table program broadcast over the NBC network. Their remarks were later criticized by David Lilienthal, former Chairman of the AEC. Below we present the text of the broadcast, excerpts from Mr. Lilienthal's attack on it, and Dr. Szilard's reply.

After a few preliminary remarks in which the subject was announced and the speakers introduced, the discussion proceeded:

MR. BETHE: I was against talking about the H-bomb before the decision to make it was made, because, in this way, I think that we unnecessarily gave the Russians some information—the information that we consider it feasible and the information that we are making it. This, more or less, forces them to do the same.

MR. BROWN: You were against the discussion then. Why are you in favor of it now?

MR. BETHE: Now that this has already been announced, I think that the main thing is to bring before the public all the relevant factors which are necessary to form an enlightened policy on this matter.

MR. BROWN: On the other hand, you hear people saying, "Why should we worry about something which does not exist?"

MR. BETHE: I believe that the time to discuss this bomb is now. If we do not discuss it now, then thoughts about it will become frozen in our government and especially in our military department. This has been the case with the A-bomb. The A-bomb could now hardly be eliminated from our armaments, because most of our strategic plans are based upon it. I would not like to see the same happen to the H-bomb.

MR. BROWN: The general discussion of the H-bomb centers around its being a weapon—a weapon which possesses a great deal of potential destruction. Could we start off this discussion by asking of what the hydrogen bomb is made anyway?

MR. SEITZ: I suppose that everyone knows by this time that it is made of heavy hydrogen, which is used in cooperation with an ordinary A-bomb.

MR. BETHE: I want to say a few words on how long it perhaps will take to make this weapon. It has not been made. It has not even been conceived definitely how it will be made. And, connected with this, are all the uncertainties which you always have in a research development. You never know what will come out of it; and, in this particular case, we cannot predict whether the bomb can be made or not.

On the other hand, on the basis of the decision which has been made, we must conclude that our experts believe that it is probable that we can make this bomb. Even so, I think that we must be prepared to expect that it will take several years before the bomb has been completed.

MR. BROWN: What about the size of the H-bomb? One sees figures, varying all the way from two to a thousand times the explosive violence of ordinary atomic bombs. Is there really any limit to the explosive violence which could be obtained, assuming, of course, that it works in the first place?

MR. SEITZ: In the testing stages it is very likely that, while we are trying to find out whether or not it will work, the bomb will not differ a great deal from the ordinary A-bomb. But since the intention is to build something a lot bigger, I think that it is clear that this will be true only in the early stages.

MR. BETHE: That is certainly right. If we use the bomb in war—if anyone uses the bomb in war—then the bomb will certainly be very large. If you can initiate an H-bomb at all, then you probably can initiate just as easily a big one as a small one. How big it is will depend only upon the amount of heavy hydrogen which you can carry in a plane or in any other device which you may use to deliver the bomb. We can assume, I think, that it is certain that a bomb used in war will be at least a hundred times as big as the present atomic bomb. The figure of a thousand had been used, and I use it for the sake of argument.

What would it mean if you had a bomb which is a thousand times more powerful than the present atomic bomb? This would mean that the range of blast destruction would increase tenfold—that a hundred times the area would be destroyed as by an atomic bomb. If a bomb were exploded at some place, then ten miles away from it there would be almost complete destruction. That would mean that a city as big as New York, the biggest cities on earth, could be destroyed by one single bomb.

MR. BROWN: When you say New York, of course, you mean the greater New York area.

MR. BETHE: I certainly mean that.

MR. BROWN: Something in the neighborhood of three hundred square miles or so probably?

MR. BETHE: Yes. And this, I think, is not all.

MR. SEITZ: There is one factor which I would like to add which concerns itself with flash burn. It is generally known that about 30 per cent of the casualties at Hiroshima resulted from flash. The flash extended out to about two-thirds of a mile. Now, the indications are that the flash effect would be at least thirty times larger in the H-bomb. That means that the flash effect would extend out to twenty miles, so that people would suffer severe flash burn at that distance.

MR. BROWN: We have the possibility of constructing a weapon which is, let us say, of the order of a thousand times the destructiveness of the Hiroshima bomb, or thereabouts. What about the cost of this weapon? Will it be fantastically expensive, or will it be relatively inexpensive?

MR. SZILARD: It is a mistake, I believe, to talk about the cost of the weapon. If we are building H-bombs and if the arms race is on, what will cost us most is not making H-bombs but rather the defense measures which we shall be forced to take. Our coastal cities are highly vulnerable against bombs. We cannot have advance fighter bases to defend New York or Baltimore or Washington. If we go into this arms race at all, it will be lunacy not to take defense measures. In the case of these coastal cities, it means dispersal of the population.

MR. BROWN: To what extent do you feel that dispersal will have to take place? What scale of dispersal are you thinking about?

MR. SZILARD: If I try to figure out in terms of dollars what the President's decision means, I would say that within a few years we will be up to twenty-five billion dollars as a general defense expenditure—including fighter planes, fighter bases, radar screens. And for dispersal purposes I think that we will spend at least fifteen billion dollars a year. This makes a total of forty billion dollars. But when I talk of forty billion dollars per year for defense, I assume that we are balancing the budget, because, if we do not balance the budget, we will have inflation, and the figures in dollars will be very much higher.

MR. BETHE: I am surprised that you are using such a small figure as fifteen billion for dispersal. Do you not want to disperse the inland cities, too? Is it not likely that they also will be attacked by planes or, maybe, by guided missiles?

MR. BROWN: It seems reasonable that the inland cities are less vulnerable due to the possibility of setting up rather elaborate ground-base radar screens and so forth. I certainly agree with Szilard that our coastal cities are far more vulnerable. However, if we do think in terms of dispersing our inland cities, such as Detroit and Chicago, that will add enormously to the estimate of the expense which you have already made, Szilard.

MR. SZILARD: I was thinking in terms of dispersing within ten years, and I did not go beyond fifteen billion dollars, because I think that we cannot afford to pay more. If we want to disperse all our cities, we would probably have to spend something like twenty-five billion dollars a year; and in ten years we could have very good dispersal.

MR. BETHE: How much dispersal would you envisage? Would you disperse cities of a hundred thousand or not?

MR. BROWN: Does that not depend mainly upon the types of industries about which we are talking? For example, there are many cities which are relatively small but where one particular industry is enormously concentrated. In spite of the relatively low population, you would probably want to disperse that particular city.

MR. SZILARD: I would say that about thirty to sixty million people would have to move in a general dispersal; and I should think that, before we would do that, we would take care of our coastal cities. This other measure would be a later stage.

MR. BETHE: It certainly seems hardly to make sense to go into offensive H-bomb development without the defensive development to accompany it.

MR. BROWN: I wonder whether such a development could actually be accomplished. I have the feeling that there would be tremendous resistance upon the part of our larger industrial manufacturers. Certainly they could not be expected to carry on the operations themselves. It would have to be done entirely at government expense essentially. Then one gets into other factors. Let us suppose that a manufacturer in Pittsburgh is moved out to Kansas some place. Will he be able to compete? It seems to me that any marked dispersal movement would really cause an enormous economic upheaval in this country.

MR. SZILARD: It certainly would mean planned movement. It would mean controls much stricter than we ever had during wartime. It would be not a New Deal, but a Super, Super New Deal.

MR. BROWN: We have been discussing thus far the hydrogen bomb in terms of destruction by blast and in terms of delivering it over a target. One sees in the press, from time to time, statements concerning destruction by another source—namely, radioactivity. How would you look upon that particular danger? Will dispersal actually help if H-bombs are used not for blast but for radioactivity?

MR. SZILARD: In this case, it will not help at all.

MR. BETHE: You are certainly right when you emphasize the radioactivity. In the H-bomb, neutrons are produced in large numbers. These neutrons will go into the air; and in the air they will make radioactive carbon 14, which is well known to science. This isotope of carbon has a life of five thousand years. So if H-bombs are exploded in some number, then the air will be poisoned by this carbon 14 for five thousand years. It may well be that the number of H-bombs will be so large that this will make life impossible.

MR. SZILARD: Yes, that is true, Bethe. But that is not what I had in mind, because it would take a very large number of bombs before life would be in danger from ordinary H-bombs.

What I had in mind is this: The H-bomb, as it would be made, would not cause greater radioactivity than that which is due to the carbon; but it is very easy to rig an H-bomb, on purpose, so that it should produce very dangerous radioactivity. Most of the naturally occurring elements become radioactive when they absorb neutrons. All that you have to do is to pick a suitable element and arrange it so that the element captures all the neutrons. Then you have a very dangerous situation. I have made a calculation in this connection. Let us assume that we make a radioactive element which will live for five years and that we just let it go into the air. During the following years it will gradually settle out and cover the whole earth with dust. I have asked myself: How many neutrons or how much heavy hydrogen do we have to detonate to kill everybody on earth by this particular method? I come up with about fifty tons of neutrons as being plenty to kill everybody, which means about five hundred tons of heavy hydrogen.[1]

MR. BROWN: You mean, Szilard, that if you exploded five hundred tons of heavy hydrogen and then permitted those neutrons to be absorbed by another element to produce a radioactive substance, all people on earth could be killed under the circumstances?

MR. SZILARD: If this is a long-lived element which gradually settles out, as it will in a few years, forming a dust layer on the surface of the earth, everyone would be killed.

MR. BROWN: You would visualize this, then, something like the Krakatao explosion, where you would carry out, let us say, one large explosion or a series of smaller ones. The dust goes up into the air and, as was the case in that particular explosion, it circled the earth for many, many months, and even years, and gradually settled down upon the surface of the earth itself?

MR. SZILARD: I agree with you, and

you may ask: What is the practical importance of this? Who would want to kill everybody on earth? But I think that it has some practical importance, because if either Russia or America produces H-bombs—and it does not take a very large number to do this and rig it in this manner—you could say that both Russia and America can be invincible. Let us suppose that we have a war and let us suppose that we are on the point of winning the war against Russia, after a struggle which perhaps lasts ten years. The Russians can say: "You come no farther. You do not invade Europe, and you do not drop ordinary atom bombs on us, or else we will detonate our H-bombs and kill everybody."

Faced with such a threat, I do not think that we could go forward. I think that Russia would be invincible. So, some practical importance is attached to this fantastic possibility.

MR. BROWN: Do you think that any nation would really be willing to kill all people on earth rather than suffer defeat themselves? Would we be willing to do it, for example, do you believe?

MR. SZILARD: I do not know whether we would be willing to do it, and I do not know whether the Russians would be willing to do it. But I think that we may threaten to do it, and I think that the Russians might threaten to do it. And who will take the risk then not to take that threat seriously?

MR. BROWN: In connection with the production of radioactivity, we have discussed it thus far in terms of killing all people on earth. Can one visualize a mechanism by which one produces a radioactivity of, let us say, a short lifetime which can then be carried over an area in a more or less controlled manner, so that, for example, it would be possible for a nation to kill all people in the United States without killing themselves, or vice versa?

MR. SZILARD: This is a funny question, because this is what the situation is. Of course, it takes very many less H-bombs to kill all Russians by radioactivity or to kill all Americans by radioactivity than to kill all people. But you have to get this radioactive material to Russia or to America. Let us assume that we cannot deliver our H-bombs, because they are too big. Then the temptation will be great to rely upon the westerly winds to disperse the radioactivity over Russia or over America. But whether this is possible or not depends upon the answer to a number of meteorological questions, and that answer is not known to anybody. On this aspect of the question, I would say that we leaped before we thought when we decided to make H-bombs.

MR. BROWN: In that particular connection, would you like to express any opinion concerning the relative vulnerability of Russia and the United States? It would seem to me, offhand, that with our whole West Coast exposed to the westerly winds and having the whole Pacific Ocean to operate in, if that kind of thing can be done, we are placed at a considerable disadvantage, relative to Russia, in that respect because we have Western Europe to consider.

MR. SZILARD: This one factor is in favor of the Russians; but there are other factors involved. The whole question of getting radioactive elements to settle over a given territory is difficult. To know whether it is possible to rely upon the westerly winds in any given situation is difficult. The weather conditions change and have to be taken into account. It is uncertain, I think, whether this can be done; we will not know for a number of years.

MR. BROWN: But we are agreed that that is certainly a possible use of the H-bomb which cannot be ignored.

MR. SZILARD: It is not only a possibility but a very serious possibility.

MR. BROWN: Then we are faced with the ironical conclusion in this respect that it becomes easier to kill all people in the world than just a part of them.

MR. SZILARD: This is definitely so.

MR. BROWN: How did this question of the discussion of H-bombs start in the first place? It seems to me that I remember down in Oak Ridge and at the University of Chicago during the war we discussed the possibilities of thermo-nuclear reactions to a considerable extent. That was eight years ago. Scientists have recognized for eight years now that, essentially, a hydrogen bomb might be possible. Why has the discussion not come up until now?

MR. SEITZ: The most important factor in causing all the excitement at present is the fact that the Russians attained the atomic bomb in September, 1949. This fact indicated that we no longer had a monopoly and, as a result, that we have some reason to be concerned.

MR. BROWN: That is connected then with the fact that it requires an ordinary atomic bomb to set off an H-bomb?

MR. SEITZ: That is right.

Some of the scientists who worked on the project during the war were pretty sure that the Russians would have the bomb about this time; but this feeling was not very widespread, and naturally even those scientists could not be sure.

MR. BROWN: Do you not suppose that there was another factor involved in that—that some scientists themselves sort of had their stomachs full of bomb development during the war and just got away from it?

MR. SEITZ: That was a big factor. There is an interesting situation which is occurring at the present time. Scientists have a great many viewpoints, rather different, I think, from the situation that we had in 1939 and 1940 when there was a rather high degree of unanimity of viewpoint about working on the atomic bomb. There is one large group of scientists who feel that the most significant fact about the existing situation is that in 1945 the United States and England reduced their arms budgets by a factor of about ten. Essentially we became disarmed. Russia, in contrast, has continued her armament at the wartime level and seems to be devoting major effort to it—I would guess with tremendous effect judging from the speed with which they developed the A-bomb. Probably they are working three times faster than we are. There is a great danger, if this continues, that we shall fall into an inferior military position and lose our bargaining power. In order to circumvent this, this group of scientists of which I speak feels that we are going to have to speed up our military development. The H-bomb is one aspect of this. This group in the main feels that the H-bomb is not the entire situation. There are other things which have to be kept in mind which are every bit as important. For example, there is the problem to which Szilard referred of delivering the bomb. We have to know whether we can deliver the things which we make. I would say that the whole program of military development should be considered as one coordinated unit. Then there is another important point. I would say that all scientists feel that our primary goal should be peace and that any reactivation of military affairs which occurs now should be carried out as a tool to achieve peace through negotiation.

MR. SZILARD: It would be easy for scientists to agree that it is important to improve our bargaining power; but what disturbs many scientists I know

is that we do not see what we are bargaining for.

MR. BROWN: A few days ago, Bethe, I noticed in the paper a statement signed by you and eleven other scientists to the effect that the United States government should make a statement pledging us not to use the H-bomb first. Could you tell us a little bit about your considerations which went into that statement?

MR. BETHE: I certainly would like to. It was our belief that the main reason for us—perhaps the only reason for us—upon which it is valid to make the H-bomb is to keep our bargaining position and not to be confronted, one day, with an ultimatum from Russia that they have the H-bomb and can destroy us. If this is our only reason, then we thought that we would never use this bomb in an offensive war. Then we could contribute a great deal by stating this reason openly—by stating openly that we would not be the first to use the bomb in war.

MR. SZILARD: I read the statement, and I was really more impressed by the sentiment in it than by its logic. I think that what was behind the statement is a general uneasiness which I notice in many scientists. In 1939 when we tried to persuade the government to take up the development of atomic energy, American public opinion was undivided on the issue that it is morally wrong and reprehensible to bomb cities and to kill women and children. During the war, almost imperceptibly, we started to use jellied gasoline bombs against Japan, killing millions of women and children; finally we used the A-bomb. I believe that there is a general uneasiness among the scientists. It is easy for them to agree that we cannot trust Russia, but they also ask themselves: To what extent can we trust ourselves?

MR. BETHE: This is quite right, and one of the reasons which we had for our statement was to prevent the military of either country, either Russia or the United States, to start a war with the hydrogen bomb, just in order to be the first.

MR. BROWN: We are in agreement that if the hydrogen bomb works, world-wide destruction on an unprecedented scale will be possible. First, entire cities of the size of New York, Chicago, and London could be destroyed by the blast effect. But, far more important, radioactivity could be produced and could be scattered over the countryside in such a way that all life on earth, or at least most life on earth, could be destroyed.

The second point of importance is that the cost of such a hydrogen bomb will not be only the cost of the bomb itself but the fantastic cost involved in carrying out a proper dispersal program which will permit us at least to have more security than we would have without dispersal.

[1] If fifty tons of neutrons are absorbed by a natural element which is transformed into a radioactive element that emits between one and two gamma rays per disintegration having an energy between one and two million volts [like, for instance, radioactive cobalt], and if the radioactive substance produced is uniformly dispersed over the surface of the earth, then a person who is exposed to the gamma rays will receive an X-ray dose of the order of 10,000 r units by the time the radioactivity decays. If an X-ray dose is given within a short period of time, 1,000 r would be lethal; but if the dose is given over a period of years, a larger dose is required for killing.

Fifty tons of neutrons should be produced if about 500 tons of heavy hydrogen is actually "burned." Since not all the neutrons emitted will necessarily be "burned" in the explosion, the actual amount of heavy hydrogen that has to be accumulated might be considerably larger than 500 tons.

If 10,000 tons of heavy hydrogen were required, such an amount could be accumulated over a period of ten years without an appreciable strain on the economy of a country like the United States. The quantity of the natural element which has to be incorporated into the bomb in order to capture the neutrons will, however, increase correspondingly with the quantity of heavy hydrogen contained in the bombs, and there might be limitations on the raw material side for some of the otherwise suitable longer-lived radioactive elements. LEO SZILARD

Mr. Lilienthal's Criticism

Following is the New York Herald Tribune *report of Mr. Lilienthal's Town Hall address of March 1:*

"David E. Lilienthal, recently retired chairman of the Atomic Energy Commission, deplored yesterday what he described as the panic being spread by 'oracles of annihilation' who predict the end of the world through atomic or hydrogen bombs.

"Mr. Lilienthal said such pronouncements by the 'new cult of doom' served no purpose—neither the intimidation of Russia, nor the building-up of international trust, nor the cool appraisal of our military security needs. Rather, he said, they only spread a feeling of 'hopelessness and helplessness.'

" 'And hopelessness and helplessness are the very opposite of what we need,' he said. 'These are emotions that play right into the hands of destructive Communist forces.' . . .

"His denunciation of the 'cult of doom' singled out four top atomic scientists who discussed on a widely reported radio show last Sunday ways in which a hydrogen bomb might be built so as to disperse a lethal radioactive dust over the face of the earth. The four, who appeared on NBC's 'University of Chicago ROUND TABLE' conference, were Drs. Hans A. Bethe, Frederick Seitz, Leo Szilard, and Harrison Brown. (Dr. Albert Einstein made a similar warning last month.)

" 'Their concrete suggestions contained ideas the Russians may not yet have thought of,' he said. He also branded as 'highly intellectual nonsense' the speculations of the four on evacuating some 30,000,000 people from the big eastern cities. 'This can't be done, and every one knows it can't be done, so why scare the daylights out of every one?' he said.

"Mr. Lilienthal pledged himself to fostering a 'better perspective' on atomic energy by dispelling the 'black magic and hocus-pocus' connected with it as well as by stressing its vast peacetime potentialities. 'Knowledge of atomic energy has its very destructive sides,' he said, 'but so does all knowledge.'

"If people continued to regard the atomic bomb as the only aspect of atomic energy, he went on, then inevitably the bomb would become the only result of the new knowledge. Coupled with this popular feeling, he said, was the 'mountainous error that bigger and bigger bombs will make us safer and safer.'

" 'The security of this country is not a material thing but rather rests in the spirit of the people,' he said. 'We are a people with faith in each other, such a faith as has never existed in a nation before. We are a people with faith in reason and in God, but if we substitute for these a faith in weapons, we will be weakened and lost no matter how great our stockpile.'

"He concluded by calling for 'understanding instead of panic, sense instead of sensation, and courage and faith instead of fear.' "

Dr. Szilard's Reply

Leo Szilard replied to Mr. Lilienthal's criticism in the following letter to the editor of the N. Y. Herald Tribune, *published in the March 4 issue:*

"Mr. Lilienthal criticized statements which we made over the air, not on the ground that they were not true, but rather on the ground that the truth was frightening, and that scaring people served no useful purpose.

"What we said over the air we did not say for the purpose of scaring people, nor did we say it for lack of restraint.

(Continued on page 126)

THE ATOMIC BOMB AND EUROPE

Raymond Aron

Dr. Szilard's proposal that American foreign policy should aim at the neutralization of Western Europe (see his article "Let Us Face the Facts," in October 1949 "Bulletin") is considered in the letter and article below. The letter supporting Dr. Szilard's plan comes from a Parisian chemical engineer; the article, which is critical of the proposal, is written by an eminent French sociologist. Dr. Aron is a professor at the Institut d'etudes politiques and at the Ecole nationale d'administration and is diplomatic correspondent for "Figaro."

TWO years ago, the *Bulletin of the Atomic Scientists* asked me for my views on the relation of the atomic bomb to European psychology. I have been impeded in fulfilling this request by a kind of moral paralysis. What could one say on this subject which would not be negative and discouraging?

Western Europe has succeeded in getting accustomed to its worries, but not in surmounting them. She fears the Soviet Union; at least the enormous majority of anti-Communist Europe fears the formidable power which is spreading a tyrannical regime. To the extent to which the forces of the United States protect this old, disarmed continent, the Europeans have seen, in the atomic bomb, one of the guarantees of their safety. But the protection given by the atomic bomb leaves room for fear.

In so far as the bomb prevents the outbreak of war; in so far as it is the weapon preventing the cold war from degenerating into a hot war, it is a good thing. But, on the other hand, if war breaks out despite this deterrent, the bomb, although it may increase the chances of final victory for the United States, will probably add to the scope of destruction and increase the risk of the occupation (albeit temporary) of Western Europe by the Soviet Army. The Europeans, however, are almost as much afraid of occupation as they are of war. Russian occupation would lead to a social revolution and finally, perhaps, to the destruction of the national elite by purges and deportations. Furthermore, the French have learned by experience that bombardment by allied aviation, although inspired by good will, does not therefore spread less ruin and sorrow. This explains the mixed feelings of Europeans about the atomic bomb, the American program of strategic air offense, the controversies centering on the B-36, and the Homeric bragging about bombs which will be 6, 600, or 1,000 times more powerful than that of Hiroshima. The more American rearmament efforts become concentrated on strategic aviation, the more clearly can Europeans see in this program the intention to achieve victory by striking the enemy in his heart, but at the same time delivering to him the territory adjacent to his frontiers.

So it happens that the Europeans, and the French in particular—individuals as well as leaders—loudly clamor for the organization of European defense. In ratifying the Atlantic Pact, the French National Assembly has asked the Government to solicit from the United States accelerated and reinforced military aid. In French writing on the subject, the distinction between the firm promise of the United States to fight *for* Europe and the conditional promise to fight *in* Europe has become universal. It is this conditional promise that the Europeans would like to see amplified and made more precise. However, the Europeans have only rarely thought consciously of the fact that the strategic plans of the

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PARIS
November 30, 1949

DEAR SIRS:

I have read in the paper *Le Monde* of October 29, 1949, extensive extracts from Dr. Szilard's article in the October issue of the *Bulletin of the Atomic Scientists.*

May a Frenchman, who has served as an officer in two world wars and who is an engineer-scientist, offer the author his warm congratulations on this article. Many professors at the University of Paris also share my appreciation.

A great many Frenchmen have been apprehensive about the signing of the Atlantic Pact, which, in its present form, brings us more risk of destruction than hope of safety. We believe that it would have been better to have proclaimed our neutrality as the Swiss, the Swedes, etc., have done during the past two wars.

And now Dr. Szilard proposes that our country be freed from the obligations of the Atlantic Pact, without being abandoned to her sad fate in case of an invasion of Western Europe. I believe that this is the counsel of reason and hope that American public opinion will follow him.

I am convinced that we would be able to achieve a kind of national unanimity which would permit us to establish a purely defensive system, the efficacy of which certainly would be superior to that which would exist under the grandiose plans of the Atlantic Pact, for I ought to tell you that the heart of the country is not in it, and that with this pact, the American General Staff is in for a great disillusionment.

Please accept my best wishes,

Sincerely yours,
D. FLORENTIN

Formerly Director of the *Service des Poudres* and of the *Laboratoire Municipal de Chimie de Paris. Légion d' Honneur. OB.E.*

American General Staff will ultimately depend, at least in part, on what Europe herself does. Nations which are not resolved to defend themselves are not defended by others.

Such was the situation up to the moment when President Truman announced an atomic explosion in Soviet Russia. The threat of a *casus belli* was sufficient to stop the Soviet Army. The Politbureau, whatever its future intentions, is, for the time being, afraid of a general war. The Atlantic Pact, even reduced to a unilateral obligation undertaken by the United States not to tolerate aggression directed against any of the non-Soviet European states, suffices for the time being to protect Europe and keep the peace. As to the rearmament of Europe, some attach to it only a symbolic importance, some a real significance, if only for a future time. It is important, these say, that Europe be armed three or five years hence, when the ratio of force will cease to be such that one can reasonably trust in the pacific disposition of the Kremlin.

FRENCH REACTION TO THE SOVIET ATOMIC EXPLOSION

Normally, the news of the atomic explosion in Russia should have deeply stirred the European countries. If the relative moderation of the Soviet Union was attributable to the atomic monopoly of the United States, one could now foresee rapidly increasing aggressiveness on the part of Moscow. If one relied on atomic protection in order to accomplish, within a few years, the rearmament of Europe, the plans now seemed to require a radical revision—at least in their timing. Neither of these two matters was seriously discussed in France, and my impression is that discussions have not been more substantial or serious in other European countries, with the possible exception of Great Britain.

What is the cause of this seeming indifference of French public opinion, and perhaps of the public opinion of Europe as a whole, in the face of an event whose repercussions on the fate of the old continent promise to be enormous? The first reason, and the most important one, seems to me to be very simple. Not being able to conceive of a future which is not terrifying, the nations have almost renounced thinking of the future at all. They live from day to day. The state of half-war, half-peace suffices in the absence of a true peace. This is why the first reaction of commentators was to reassure their readers and reassure themselves that, for the moment, nothing had changed. That was all that was needed for everybody to return to his daily business even more resolved than before to look the other way—and not at the horizon, now covered with new and more threatening clouds.

In the absence of anything better, the accepted strategic scheme—rearmament of Europe with conventional arms to prevent its occupation by the Soviet Army—was continued unchanged. Did not the possession by Soviet Russia of the atomic bomb make the conventional rearmament of Europe less valuable? Under the threat of atomic bombardment, would Europe prefer to defend herself, running the danger of the complete destruction of her cities, or would she capitulate? Again, discussion was barely begun. Some imagined that from now on, New York, Detroit, and Chicago would be more menaced than London, Paris, or Rome; others hoped that the atomic equilibrium might cause this wonder weapon not to be used at all, and that, in the absence of atomic bombardments, conventional rearmament would become not less but more urgent than before. For several days, the press played with these hypotheses. Then everybody went back to business as usual. In an atmosphere of general indifference, the first pages of our newspapers were again filled with reports on the establishment of the organizations provided in the Atlantic Pact, and the implementation of the arms procurement plans.

An analysis of this indifference would lead us beyond the limited scope of the subject we propose to discuss. The atomic bomb is but one of its causes. The bomb is the symbol of two realities which are at the root of European defeatism: the enormous superiority of the material force at the disposal of the two big powers, which reduces the role of the European nations to a secondary plane; and the terribly destructive character of modern weapons, which fills the menaced nations with doubts as to the ultimate usefulness of resistance, even in the face of a detested enemy.

Under these conditions, it is not astonishing, even if it is remarkable, that the only valuable study which has tried to draw the consequences for Europe of the end of the American atomic bomb monopoly, has been the work of an American, more specifically, of an American scientist. Even more striking is that the thesis developed by the author coincides with the ideas expressed or suggested by some enemies of the Atlantic Pact in Europe. This idea is *European neutrality*. The American reader will probably find it astonishing that a European writer should oppose this thesis. But the answer will be simple:

The question to decide is not whether I would like France to remain neutral in case of conflict, but whether I consider this eventuality at all possible.

IS THE NEUTRALITY OF WESTERN EUROPE PRACTICAL?

Dr. Leo Szilard's central idea is that the neutralization of Europe offers the best, perhaps even the only, chance of establishing an armistice, and, in some future time, peace. If war should occur, it would offer the only chance of saving the old continent from an almost total destruction—which would take away most of the significance of an American victory (since one of the reasons for the war would be to save Europe).

Dr. Szilard's concept of the neutralization of Europe doesn't have much in common with the vague pacifist conception of neutrality, or with the so-called "third force" concepts, against which we, the European partisans of the Atlantic Pact, have carried on an endless fight. Under Dr. Szilard's plan, this neutralization would maintain one half, and an essential half, of the obligations contained in the Atlantic Pact. Europe will still be protected by the threat of an American *casus belli*, but it will cease to be obligated to take part if war should arise between the United States and the Soviet Union elsewhere in the world, for reasons not connected with the old continent. The United States would respect the neutrality of Europe, at least as long as the Soviet Union doesn't resort to an atomic bombardment of America. The proposal contains, therefore, two ideas, one explicit (neutrality of Europe), the other implicit (the United States and the Soviet Union would renounce the employment of atomic bombs against each other).

THE CONDITIONS FOR NEUTRALITY

In the modern world neutrality in a general war presupposes one of the two following conditions: Either the neutral country should be distant from the territory which constitutes the stake of the conflict or the theater of operations; or else it should dispose of such forces that, for the principal belligerents, the cost of occupying it would outweigh the advantages.

In the last war, the countries of South America were in the first situation, Switzerland and Sweden in the second one. Germany, if victorious, would have probably extended her influence, if not her empire, to Brazil and Argentina. But these countries did not constitute the direct stake of the conflict and were situated on the margin of the main strategic zone. The case of Switzerland is typical of the second hypothesis. The German Army could have conquered Switzerland. In all probability, in a Europe conquered by Nazis, Switzerland could not have maintained her independence. But the quality and the fighting morale of the Swiss Army was such that an invasion would have involved heavy costs and would have brought almost no advantages. The railways, of which the Germans had practically unhindered use, would have been destroyed, as well as the precision industry, which, despite neutrality, was working predominantly for the temporary masters of Europe.

It is self-evident that European nations included in the Atlantic Pact are not in a situation comparable to Argentina's or Switzerland's in the last war. They are one of the principal objects of the possible conflict. They have about 250 million inhabitants and one of the three great concentrations of industry in the world. They have been the center of modern civilization, and they are still one of the places where its spirit lives. That Europe could remain neutral in case of war is against the familiar law of conflicts for world hegemony. Such an eventuality would require the race for allies to be suspended by a deliberate agreement between the two main belligerents, contrary to all precedents. (Athens and Sparta, Rome and Carthage sought to strengthen their own arms by rallying to their banners the other nations—the undecided, the satellites of uncertain allegiance, and even the barbarians.) The paradox would be even more striking in that the two belligerents must agree in advance to respect the fruits of victory! Europe would become communistic or democratic in accordance with the result of the war. The United States and the Soviet Union would generously permit Europe to watch as a spectator the titanic conflict, the outcome of which would determine her own fate.

STRATEGIC CONSIDERATIONS

Does this unprecedented situation have a chance, even a small chance, of being realized? If war breaks out, can one hope that the neutrality of Europe will be respected by the Soviet Union? To this question I have no doubt that the answer must be NO. The neutrality which we are discussing is an *armed* neutrality, with Europe's arms supplied by the United Nations upon certain conditions—such as that they must be evacuated in case of capitulation. However, communist propaganda knows only two categories: friends and enemies. The acceptance by the Soviet Union of a neutralized Europe would presuppose a complete change in the official propaganda line, a radical conversion to a new way of thinking. More than that, the presence in Europe of a military force (which we have to assume as not insignificant in size) would constitute a very real danger to the Soviet Union. She would not be able to engage in distant and uncertain operations against the United States, leaving her land flank exposed to such danger. A neutral but armed Europe would remain capable of intervening in the ultimate phase of the conflict. How can one imagine the Russian General Staff taking this risk and renouncing the possibility of putting into the service of its own war machine, the war industries and the land armies of Europe?

IDEOLOGICAL CONSIDERATIONS

Let us concede, for the sake of argument, that these strategic conditions were eliminated. If a total war is ever to break out, it will be conducted by Moscow as a revolutionary war. A power whose ideology and whose believers all over the world are one of its main arms, will never agree to the *political* neutrality of a vast territory. How could it admit that the Communist Party can consider imperialists and socialists on the same plane? How could it renounce using the occasion to create accomplished facts in the form of social upheavals, which even an American victory could not reverse? To imagine that the Soviet Union, engaged in a war to the death, would scrupulously preserve Western Europe, which it envies, hates, and despises, means ignoring all that is known about the psychology of the present Russian leaders.

However, one could say, does not Dr. Szilard's fundamental postulate retain its validity *in any case?* Is it not true that in a short while Western Europe will be at the mercy of Russia—in the sense that if it is attacked by the latter, America will not be able to come to the rescue early enough to prevent her destruction or capitulation? Let us note, first of all, that this situation—which is described to us as new—has, in fact, existed for several years. I see no reason to assume that in the last four years America was in a position to use Western Europe as a base to carry the war to Soviet territory. Only the possibility of carrying the war to Soviet territory by aerial bombardment has been open—and will remain open to the United States quite independently of what happens in Western Europe. (Air fields equipped to serve as bases for strategic bombardment are located in Great Britain, not in France; and, if they exist in Germany, they are too near the Soviet border to be usable in case of war.) As to an attack against the Soviet territory by land armies, how could the United States even think of such a possibility in the face of the ratio between the Soviet contingents which could be immediately mobilized and the small forces at the disposal of the Western allies.

It is difficult for me to avoid one conclusion! Western Europe has never been conceived by the American General Staff as an avenue of approach to the Soviet territory with the aim of invasion of the latter by Western allies. Never, since 1945, has Western Europe constituted a menace directed against the Soviet Union, but, to the contrary, has represented an open spoil for aggression. The end of atomic monopoly does not change the existing state of affairs. At most, it destroys a hope, which could have been nourished, of a Europe commanding enough conventional arms not to be destined for Soviet occupation in the first days of a possible conflict. As things stand now, one may fear that, even in possession of conventional armaments, Western Europe will be unable to resist a threat (or the actual occurrence) of atomic bombardment.

Let us admit that Dr. Szilard is right on this point, and that tomorrow Europe will be at the mercy of the Soviet Union. What new aspects of the world situation will result from this? Is it that Europe must now remain neutral if the world war breaks out in some other part of the globe? Today, in the possession of the atomic bomb, the Soviet Union will be even less inclined to tolerate such neutrality than she might have been yesterday, when she had at her disposal only the so-called conventional arms. Is it that Europe must announce in advance that she is going to capitulate?

That would be a policy of madness. Is it that Europe should join the Soviet camp? That, too, would be stupid. There remains one single hypothesis, the one which is included implicitly in Dr. Szilard's proposition: the renunciation by the United States of the initiative in the use of atomic bombs.

It is not easy for a European to say what he thinks of this proposition. If war should occur five or ten years from now, at a time when both camps have accumulated a stock of bombs, no doubt the best chance for Europe would be the neutralization of atomic arms by mutual fear of reprisals. If such neutralization occurs (which is improbable but not unthinkable), Europe, rearmed with conventional arms, would have a chance of avoiding occupation. But no one who is not an American can say to the Americans: Proclaim solemnly that you are not going to be the first to use atomic bombs. The one who takes the initiative in this field will assure himself of immense advantage; and renunciation of atomic bombardment will logically imply an increased effort on the part of the United States in other military fields.

WOULD THE NEUTRALIZATION OF EUROPE AFFECT THE COLD WAR?

If we assume that Dr. Szilard's plan will in no way affect the course of the war *once it has started*, could it, at least, affect the course of the cold war, permitting, first, the conclusion of an armistice, and then, the realization of peace? If we leave aside certain episodes, which, although sensational, were local in character, like that of the Berlin blockade, the cold war has grown out of the action of Communist parties all over the world, out of the vulnerability of entire regions such as Asia, and out of the division of Europe and, in particular, Germany. The arms race undoubtedly constitutes a complementary aspect of the cold war, which rages all across the planet, and which is primarily political—in Greece and in Asia it has already degenerated into open fighting. However, as long as the Soviet Union remains what it is—closed, mysterious, and dedicated to daily imprecations against the world outside; as long as the Communist parties remain what they are—tyrannical when they attain power and resolved to conduct continuous sabotage when they are out of power, the inquietude of humanity will continue. For what reason would impel the Soviet Union and the Communist Party to change their behavior? Why would the Communists of France, or of Italy, cease to sabotage the bourgeois democracy—since they consider capitalism as the absolute evil and communism as the absolute good, or at least the first as a thing of the past and the second as a thing of the future? In other words, the cold war is linked to the fundamental facts of the present world (the relationship between the Soviet Union and the Communist parties of the world, the weakness of bourgeois democracies in Europe, the social disintegration in Asia), and it is in nobody's power to change the situation between today and tomorrow. In this sense, what I call the "war-like peace" and what Dr. Szilard calls "neither war nor peace," does not represent a short period of diplomatic tension but *an inevitable state of the world* in the historical period following the Second World War.

COULD THE ARMS RACE BE HALTED BY AGREEMENT?

Abstractly, one could conceive that the other aspect of the cold war—the arms race—could be altered by an agreement. But an agreement on the reduction of armaments presupposes a mutual confidence which cannot arise—since it doesn't exist at present—except by the implementation of a system of effective control. Until now, all attempts at this have failed. Could the proposals to neutralize Europe and to renounce the initiative in the use of the atomic bomb, create a new situation and break the deadlock?

Consent to the neutralization of Europe would be a Russian concession. The agreement not to be the first to use the atomic bomb would be an American concession. I am not certain that Soviet Russia is ready to make the first, and the United States, the second. But let us assume that the two concessions have been made. The United States, however, will not cease to develop atomic researches; the Europeans will not cease to arm themselves; the Russians will not cease to isolate themselves behind the Iron Curtain, to accumulate arms, and to inveigh against capitalism. To repeat, it rests with the United States alone to declare or not to declare that they are not going to initiate the use of atomic bombs? I doubt that the military leaders of the United States would consent to such a declaration, so great is the advantage of initiative in this matter. Aside from this declaration, implicitly envisaged by Dr. Szilard, all the rest will be carried away like straws if war should break out; while the immediate future will bring no change, or very little change, in the development of the cold war.

CAN "CONTENTMENT" REPLACE "CONTAINMENT"?

Dr. Szilard gives as an explicit objective of his suggested political moves, the changing over from "containment" to "contentment." Is it true, however, that the United States has surrounded the Soviet Union by very strong pressure from all sides? Not at all. The United States has restricted itself to protecting the oceanic fringe of Europe, and, in all probability, will protect tomorrow the oceanic fringe of southeastern Asia by threatening to make any invasion of this fringe a *casus belli*. Logically, in every part of his immense empire Stalin remains the stronger of the two. In a few days, if not in a few hours, his airborne divisions could be at Brest if he should choose to order them there. There is no pressure on the Soviet Union, unless free and relatively prosperous countries represent to Soviet Russia an insupportable threat by their very existence. There is simply the perennial rearmament and verbal agitation on the subject. As to the contentment of the Soviet Union, this hypothesis has sense only on one condition: that Stalin, in contrast to Hitler, is capable of being satisfied without grave injury to the interests of other nations. Dr. Szilard says, YES; I say NO.

As long as one bases one's arguments on vague generalities, such as the assertion that Soviet policy is above all Russian policy and only secondarily communist policy, or that communism is at the service of Russian ambitions and not the other way around, one can talk and talk. Neither the concept of "Russian policy," nor the notion of "communist policy" is very clear in itself. There is only one real way to advance, and that is through observation of the sum total of known facts.

1. The official doctrine of the regime as exposed by Stalin in all his serious writings, that is, writings destined for the use of the Communist Party, is that the rivalry between the capitalist countries and the socialist countries is permanent and fatal; that it will create trouble and wars until the final victory of socialism. There is no more reason to doubt the sincerity of Stalin and his companions when they expound such theories than there was to doubt the sincerity of Hitler's ambitions, exposed in *Mein Kampf*.

2. Wherever the Soviet armies have penetrated as liberators, they have pro-

ceeded, by the use of a technique that is well known by now, to the sovietization of the country. Poland, Romania, Bulgaria, Czechoslovakia, and Hungary, have all been victims of this same technique. This sovietization, aided by the presence of the Red Army and directed by the emigrants who have lived for years in Moscow, has been accepted as the standard form of revolution in the present phase of history. The theory makes no distinction between a revolution created by spontaneous mass movement and a "prefabricated" revolution. Quite officially, the defeat of the Communist parties in France and Italy is ascribed to the absence of the Red Army. The use of the latter in the case of revolution is considered legitimate.

3. The sovietization of Eastern Europe has not been a fear reaction to the atomic bomb. The best proof of this is that it was initiated even before the dropping of the bomb on Hiroshima. The sovietization of Poland was implied in the creation of the Lublin Committee, which was accepted in Yalta by the Western statesmen. Mr. Vishinsky imposed the Groza cabinet upon King Michael in the autumn of 1944.

4. The fate which has stricken Eastern Europe will overtake any country in Europe into which the Soviet Army penetrates. There is only one limit to the advancement of this army—the limit set by the fear of general war. For four years the Soviet Union has pushed as far as possible, but has taken all precautions not to create a *casus belli.*

So far, we have merely summarized the facts which seem to me incontestable. They suffice to show the extent to which it is nonscientific to conceive a move toward peace by "contentment" of Stalin. Can Stalin be content as long as the encirclement by the capitalist world remains? Can this encirclement end as long as socialism has not engulfed the world entirely?

It is very true that, as far as one can judge, the communist leaders have not fixed a timetable for the communization of the world. It is probably true that they have no such general plan. They have never used military means, or, at least, never under conditions such as to lead to the danger of general war. If a day comes when they might conclude that the ratio of forces is favorable to them, will they maintain the same prudence? Nobody knows. All that one can say is that reason calls upon us never to let the situation arise in which the Politbureau might consider their final victory as probable.

One may say that if the conquest of the world by communism remains a more or less remote objective, does this not mean that at least a temporary truce is feasible. One forgets that even if the Soviet Union does not plan to conquer the whole world within a few years, she does not intend to leave the capitalistic world alone to stabilize itself in peace. Until now—and nothing permits us to expect a change—the communist strategy, if it does not include open general war—does not include stabilization either. The cold war, in the form of sabotage of the part of the world not yet converted to socialism, is a distinctive trait of this phase of history. The leaders in Moscow see advantages in this situation: the weakening of the enemy and the justification of the restraints imposed on the Russian population in the name of social reconstruction and external danger.

The terrorism, once it has become essential to a certain regime, maintains and amplifies itself indefinitely. It is always in need of new enemies. When it has no real ones, it invents them. A "contented" Stalin would have to give to his people the right to be content in their turn. Once again, we have to assume a conversion of the Soviet regime which we might wish, but on which it would be folly to rely.

WHAT SHALL WESTERN EUROPE'S COURSE BE?

Some might tell me that this is purely negative criticism. What do I propose in place of the neutralization of Europe? Will other possible political programs be better than the one I am refusing to accept? There are two such alternative policies: the so-called preventive war initiated by the United States in the next few years, or the continuation of the cold war. Let's disregard the preventive war, which is not a useful subject for discussion. Dr. Szilard asserts that the continuation of the cold war must *inescapably* lead toward war "at the moment when the conflict will be the most terrible." He may be right, but it is a question of greater or lesser probability, the estimation of which varies from observer to observer, and not of certainty. As long as the Soviet Union is afraid of general war, she will abstain from creating a *casus belli,* and the cold war will retain the same limited character which distinguishes it at present.

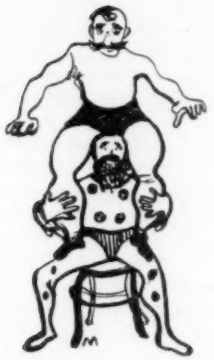
"This situation cannot endure." Why? From Moscow's point of view, it is normal. The democracies, it is true, are not inclined to resign themselves to it, but except by throwing themselves into hot war to end the cold war, they have no way to end it. Which of the two sides will take the resolution to begin total war? Among the multitude of possibilities which can be envisaged, here are the ones which seem the most probable to me. First of all, there is the fear of the advantage which the enemy might acquire by striking first, and, from this point of view, and none other, the scientific armaments, such as the atomic bomb, bring a new factor into the classical arms race. Undoubtedly, this constant and mutual fear is going to poison the atmosphere. Does it mean that one or the other side will end by striking out of fear that the enemy will do it first? Once again, it is possible, but by no means certain. The second possibility is that Stalin may have too much success in the cold war. If communism conquers southeastern Asia after conquering China, a moment might arrive when the Western world would have no other means of saving itself except by total war. However, this eventuality is by no means near at hand. It can be contested by continuing a cold war with energy in the political as well as in the economic fields. Another and greater possibility is that the Soviet Union, on the day it has acquired a stockpile of atomic bombs, will adopt a more aggressive attitude and trespass, in one or another part of the world, upon interests which America considers a *casus belli.* It doesn't depend on us alone whether or not this danger is going to be eliminated. The best that Americans can do is to maintain their superiority in armaments and every time a particular problem arises, not to leave the slightest doubt as to the attitude they intend to adopt. It would be too stupid if the total war is caused by a misunderstanding!

The indefinite continuation of the cold war is not a prospect calculated to arouse enthusiasm. Yet it is the only one which appears real under the present conditions. It is only far away on the horizon that one can perhaps expect a new climate to arise. This new climate can only be created by an internal transformation of the Soviet regime, transformation which nothing permits us to expect at the present, but which, if not probable, is, at least, not impossible after the death of Stalin, when the ruling class

(Continued on page 125)

CAN PHYSICS SERVE TWO MASTERS?

F. Wheeler Loomis



The dualism in the motivation and practice of physics is analyzed in the following article by Dr. Loomis, Head of the Department of Physics at the University of Illinois and wartime Associate Director of the Radiation Laboratory at the Massachusetts Institute of Technology.

THE title of this article refers, of course, to the passage from the Sermon on the Mount "No man can serve two masters: for either he will hate the one and love the other; or else he will hold to the one and despise the other. Ye cannot serve God and mammon."

THE DUALISM IN PHYSICS

There has always been a well-recognized dichotomy in the motivation and in the conduct of physics.

The names given to it will depend somewhat on the point of view. One may contrast the aesthetic with the practical; or pure physics with applied; or research with development; or free inquiry with programmatic investigation.

Whatever you call it, the relation between the two parts of this dualism is a true symbiosis: each stimulates and assists the other. Neither could live very vigorously, neither would have developed to the degree that it has, without the other.

It was the problem of detecting the adulteration of the gold in Hero's crown that led to the discovery of Archimedes' principle.

Many early physicists were primarily considered in their day as military technicians: Archimedes, Leonardo da Vinci, Galileo, Lagrange, Laplace, and Carnot, for example.

Kepler's and Newton's laws were based on measurements made primarily for astrological purposes; and chemistry developed out of alchemy. And these are just as good instances of the stimulation of pure science by practical demands as if the problems had been sound and the sincerity of the pseudo-scientists less questionable.

It is no accident that the great development of thermo-dynamics in the early nineteenth century, with the discovery of the first and second laws, followed the invention of the steam engine.

It is no accident, either, that Planck's discovery of the quantum followed the introduction of new sources of illumination—the Welsbach mantel and the electric lamp—and was rather directly stimulated by the somewhat commercially motivated studies of radiation that were being carried on in the Reichsanstalt.

There is no point in emphasizing the other aspect of the symbiosis, the contributions of pure physics to applied physics, to industry, and to military uses. It is too obvious. Essentially the whole of applied physics derives, directly or remotely, from basic physics. Such major instances as the development of our whole electric industry from Faraday's discovery of electromagnetic induction, or the rise of modern communications from J. J. Thomson's discovery of the electron, could be multiplied a thousandfold by others in which the connections are more diffuse but no less real. Undoubtedly, in the aggregate, day-to-day use of the principles of basic physics in the solution of applied problems is more important than these striking instances.

I have made these rather obvious points at the beginning to make it plain that, although I shall identify basic physics, the search for the understanding of nature, as the master, I have no intention of deprecating applied physics; that I haven't forgotten that physics would not have progressed as it has, without the incentive of practical needs. And naturally I take pride, as we all do, in the impressive contributions which our science has made to industrial civilization and to our victory in the war.

Nevertheless, this dualism of which I spoke, this difference between the motives and values of pure and applied physics, exists and has consequences that we must face. We all have to adjust ourselves to it in one way or another.

PHYSICS AS AN ART

Let's start by considering the motives that impel us to become physicists and devote our lives to physics.

It seems to me that they are almost wholly aesthetic. There are many among physicists who would see no meaning in this statement. And it is true that the charm of physics has none of the sensuous element in it. At least 90 per cent of the students now beginning the study of physics in the schools and colleges would find the statement that physics is beautiful, distinctly funny. So perhaps I may be forgiven for laboring this point.

Consider the subject of falling bodies as it develops in the early days of a course in elementary physics. Take one of those standard problems in which an object is thrown straight up, pauses at the top, and falls down again. Note the effect on a bright student when he first realizes that he needn't break it up into two problems, that there is a generality in the convention of algebraic signs, and a meaning in the continuity of the variables, that fits the physics in an essential way, that carries him over the hump and down again in one continuous process.

I consider this, though elementary, a direct aesthetic experience which differs in degree but not in kind from the

Based on an address given before the American Physical Society in New York on February 3.

more complex ones which follow as the subject develops; the appreciation of the ultimate simplicity and generality with which Newton's laws of motion and of gravitation represent all the intricacies of the motions of the planets; the general mechanical principles expressed in terms of generalized coordinates; the sublety and depth of the statistical concepts of temperature and entropy, and so on. The whole process of becoming acquainted with the power and generality of physical laws and the elegance of their mathematical expression is a rich and satisfying aesthetic experience. One can even offer the explanation, that this is because physics satisfies the aesthetic criterion for the highest forms of art: simplicity and relatedness resolving superficial complexity.

The aesthetic element in purely experimental physics, in what we call gadgetry, is probably to be found in the pleasure of exercising control over nature. Doesn't that express the kind of satisfaction a small boy, or his father, gets out of an electric train?

Or, as about the lowliest instance of real gadgetry I can think of, consider the humble radio ham. What is his motivation? He surely is not engaged in practical communication. Anyone who has ever listened to the banalities that are propagated over his portion of the spectrum can discard that theory. Why does he consider it fun? I submit that it is because, with just enough difficulty, he is controlling nature in the form of his circuits and vacuum tubes and the radio waves. It is even not much of an exaggeration to apply religious phraseology to his motives. You could say he spends long night vigils in contemplating the mysteries of action at a distance and in propitiating the caprices of the Heaviside layer.

But controlling nature is not enough. Any adolescent boy can exercise tremendous power over nature by driving a car. Art and ingenuity and the overcoming of difficulties have to enter if it is to be really interesting. Perhaps that is essentially why only new experiments deserve serious attention.

The processes of the theorist and the experimentalist aren't essentially different. Both are asking questions of nature: the one, so to speak, with mathematics, the other with instruments. To both, the questions, the thought, the underlying nature of the physical world, are the essential interest. And, the development of techniques of competitive collaboration between the two is perhaps the clue to the accelerating speed of progress in physics.

Note that a good experiment is one which asks a significant question of nature and gets a reliable reply. A beautiful one is one which accomplishes this with ingenuity (art) and economy of effort (ease). The criteria are again aesthetic.

PHYSICS AS AN END IN ITSELF

If we agree that we have been attracted into physics by aesthetic factors; that our appreciation of it is because of its beauty and the satisfactions of winning control over nature, then we have to conclude that, to us, physics is an end in itself. It is primarily one of the values of our civilization; one of the things which wars may have to be fought to preserve. Only secondarily is it a means, though an important one, for the winning of wars.

The misconception, that physics is primarily a utilitarian subject, pervades even the university campuses, where it is studied largely as a tool by engineers and premedics and studiously avoided by our colleagues who plan the curriculum in liberal education; or at least so diluted as to be unrecognizable. Unless one defines a humanity as a subject of which everyone thinks he understands something, or as one suitable for dinner-table conversation, physics deserves as high a rank among the humanities as any discipline whatever, and its omission will leave just as wide a gap as would the omission of philosophy or history in the appreciation of the major intellectual achievements of our civilization and the forces which affect it.

It is by far the most highly developed and successful of the sciences, in a golden age when science has immeasurably deepened man's understanding of the world. It has penetrated into age-old problems of philosophy and made progress with them; such problems as the natures of space and time and of causality. It has developed methods of thinking about them, and asking meaningful questions about them which can hardly fail to bring still deeper understanding in the future. It has developed instruments, and experiments, and mathematical methods of logical thought that have penetrated incredibly far into the outermost regions of the universe and into the innermost recesses of the nucleus. It has produced and measured temperatures from a thousandth of a degree to millions of degrees, and has extended the range of practically every other variable far far beyond any of man's natural experiences, far beyond any of the requirements of technology and, indeed, far beyond what would have been deemed possible only a short while ago.

In the process, it has repeatedly laid bare the most surprising and intricate secrets of nature: often facts or laws which the imagination would have balked at because they seemed too complex to be fundamental; and which have yet turned out, as theory has developed, to be aspects of a deeper underlying simplicity. Think of the curiously skew relation between electricity and magnetism; or of the wave particle dualism. Think of spectroscopy and the beautiful order into which it has been arranged. Think of the hodgepodge of elementary particles which has accumulated in the last few years and which can hardly fail to be the subject of another great simplification.

Some of this phraseology may seem a bit purple for a physicist. I don't apologize for it. It is appropriate to the subject.

Nor should I apologize if it were pointed out that there is a considerable disparity between this picture and the day-to-day activities of physicists. For it is of the nature of science, that it progresses mostly by steps which are slow and small but sure and cumulative, and which never need to be retraced. Most of us have to be content to be the workmen on the cathedral; to lay some stones or carve a gargoyle, never fully knowing the plans of the master-architect but only glimpsing occasionally the beauty of an arch or a pillar. But physics is a cathedral and not a factory; it is built on the solid rock of experiment, and it will last as long as civilization lasts; and without us it could not have been built.

To us, then, physics, pure physics, the quest for the understanding of the nature of the world, is the master. But to most laymen, to engineers, to industrialists, the military, and, in general, to people with immediate practical needs, it appears as a servant; more respected now than ever before, but still a servant.

To us the great names in physics are such as Galileo, Newton, Faraday, Maxwell, Helmholtz, J. J. Thomson, Rutherford, Planck, Einstein, Bohr. It is a pleasure just to mention them, because each recalls at least one profound new insight into nature.

THE PRACTICAL ACHIEVEMENTS OF PHYSICS

The layman, or even the engineer, whatever names he might mention, is likely to be more impressed by radio and radar than by the electromagnetic theory of light. He has, indeed, been struck by the speed with which physicists

can exploit the practical consequences of scientific discovery—by the interval of only seven years, for instance, from the basic discovery of nuclear fission to Hiroshima—and may have come to admit that physicists are much more practical people than he had believed. As, of course, they are. But his criterion is still usefulness—"end use," as they say in the Services.

This dualism we physicists have always lived with, but until the twentieth century, or even until the war, it has had no very strong effect on our activities: perhaps largely because the interval between basic discovery and application was usually longer than one working lifetime. So that the man who made the fundamental discovery seemed to the practical mind to be concerned with trivialities; while the application was made by later workers who perhaps considered themselves engineers. What has hit us recently has been the rise of industrial physics and especially the contributions of physicists during the war to all sorts of military problems, such as radar and the atomic bomb. It is now pretty widely appreciated that the training and skill of the physicist, his special facility with theory and instrumentation and his success with new problems, are major industrial and military assets.

Thus, the practical importance of physics has come to be appreciated as never before; and we are glad of it. We enjoy being useful and we like to be appreciated. But there is a price to be paid. If physics is valuable and important to non-physicists, then these outsiders, who do not understand it, will inevitably exercise some control over it, and there is no guarantee that the control will be intelligent.

Just as Archimedes was killed, after the siege of Syracuse, by a Roman soldier, a barbarian too rude to understand what he was destroying; so the Japanese cyclotron was destroyed, after the invasion of Japan, by order of an American soldier, too barbarous to understand the difference between a scientific instrument and a military weapon. Now I don't want to seem to compare Archimedes with what was, after all, only an instrument. But the intellectual level of the two acts was the same.

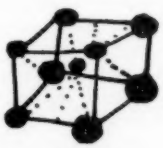
Last summer, in the name of patriotism and security, the Congress, surely without understanding the real consequences of its action, though they were pointed out by practically every scientific organization in the country, passed the rider requiring FBI investigation of applicants for AEC fellowships, thus almost completely destroying the usefulness, both to the AEC and to the nation, of a measure that had been contributing a good deal to restore the wartime deficit of scientists.

If the great increase in the public esteem of physics is going to lead to outside control of this type, we had better take a pretty sharp look at where we are going and what is to happen to us. We had better plan or we shall be planned.

BASIC SCIENCE IN THE INDUSTRIAL LABORATORIES

Let's first take a quick look at the changes that are already upon us. One of the most striking is the rise of the great industrial laboratories.

This tremendous expansion of industrial science cannot help having a major impact on the progress of pure science—for better or for worse. Pure science is certainly not the motive for building these great laboratories. If



they are to justify their continued existence, each of them will ultimately have to pay off, in a material and financial way, the corporation which supports it. Therefore, if their net effect on pure science is to be beneficial, it will have either to be accidental or it will have to be the result of very farsighted appreciation, on the part of great corporations, of the ultimate benefit of pure science to them. (Actually, it seems to me that most of the contributions to pure science by industry have, up to now, been accidental.) Fortunately, many of these laboratories at least satisfy one necessary condition for the industrial support of pure science—that the industry concerned be so large and so diversified that almost any discovery may be useful to it.

Conceivably, all this growth of industrial science could be taking place at the expense of pure science. Conceivably, and as some feared at the end of the war, industrial salaries and the excitement of development work could have seduced the formerly pure scientists away from the universities and from the pursuit of pure science, and even have dried up the source of future scientists. In general, this hasn't happened. Industrial salaries are, of course, somewhat larger than university salaries, but not as much so as is often supposed. Very few capable physicists, if any, are being forced by economic considerations into environments they dislike. Rather, it seems to me, the choices of employment are being made, as they should be, on the basis of temperament and taste; on preferences for one type of work or for another. Moreover, these industrial laboratories with their magnificent facilities, and with their resources of engineering know-how and of finished workmanship, afford, in some respects, very superior opportunities for the pursuit of pure science. Nevertheless, not so very much fundamental physical science has come out of them yet. Of the sixteen American recipients of Nobel prizes in physics and chemistry, only two—Langmuir of the General Electric and Davisson of Bell Telephone—have so far been industrial scientists.

Probably almost any director of an industrial laboratory would agree that he still has a great deal to learn about the most effective ways to use scientists; about how to ensure that a deep enough understanding is attained, even of the phenomena underlying his own industry; and how to provide enough scope for originality.

Probably any such director would be hard put to it to name an important instance in which the company's money has been wasted by the unjustifiable pursuit of pure science—although I suspect that more than one young man has entered industrial employment with the intention of doing just that. What that young man will have failed to realize is that there is comparatively little danger of his being ordered by some hard-headed superior to be practical, but rather that he will himself be seduced by the glamor of tangible results and the satisfactions of feeling useful and appreciated; and he will come to accept the values, in terms of the profit motive, the quick-return values, that necessarily prevail in industry.

Probably the same laboratory director would have no difficulty in recalling cases where he wished that certain fundamental research had been carried out earlier. At least this was the case in the Radiation Laboratory at MIT which was governed almost exclusively by pure scientists and whose short five years of life might have been expected to provide little opportunity for basic research to pay off.

I think we can conclude that, if the errors are consistently of one sign, we are not at the optimum condition, and that even industrial laboratories will

in the long run be more successful if they can achieve conditions which will favor basic science. This will require some encouragement by management to overcome an adverse climate of values. If it succeeds, these great laboratories may well become some of the major sources of real science.

PHYSICS IN THE GOVERNMENT LABORATORIES

The rise of the industrial research laboratories is only one of the ways in which the whole scene of physics, with all the circumstances of organization and support, has changed radically and rather suddenly, especially since the war. The most striking change has been the rise of the great government and semi-government laboratories. Where there used to be only our old friend, the Bureau of Standards, and a few others, there are now scores of military laboratories, many of tremendous size, many of them founded since the war; and also the great AEC laboratories.

Because of their newness and of their size and of their military nature and because they are operated, or at least closely controlled, by the government, all sorts of very fundamental problems of management have arisen; mostly old problems to be sure, but problems which this time have got to be solved.

How can science be organized on this scale, and by the government, so that it will really be as productive as it must be if we are to win the next war? How can the government make sure that originality and imagination and high intelligence and vigorous initiative are applied to its problems?

Some of the ablest and most patriotic scientists in the country are giving their best energies to this problem. Certainly there is no one simple answer to it. Certainly it needs to be worked out and fought over, step by step and detail by detail.

PROBLEMS OF ADMINISTRATIVE PROCEDURE

One major problem consists in devising administrative procedures that are appropriate to research.

Let me take time to mention two areas where the government administration of research is so inappropriate to the nature of research as to interfere with it very seriously.

Personnel Policy

The first is the personnel policy, which depends largely on job descriptions and objective classifications to determine salaries and promotions. Everyone realizes that the judgment with which salaries are set has a lot to do with the morale of an organization, so that there is hardly any function of management which is more important. And yet there is no realistic job description of an independent research scientist other than that he discover as much as he can. And there are no objective criteria of much significance; neither age, nor degrees, nor number of subordinates nor even number of publications. The discrimination has to be made in terms of somebody's judgment, and if the government can't find a way to put its trust in the judgment of the right people, the responsible scientists, it is not going to have first-rate research.

Oh, I know there are tricks by which an experienced administrator can get around the regulations—by writing job descriptions to fit particular people, and what not, when he feels strongly enough to take the time. But the routineers and the slackers know tricks, too, and more of them, and have more time to give to them. There is no way out except reliance on the judgment of responsible scientists. The procedures which are entirely appropriate for employment in standard jobs, such as clerical work, and even definite administrative posts, are entirely inappropriate to research. Adherence to these so-called objective criteria is a fundamental falsity which inevitably leads to false and harmful results.

In my opinion, government personnel policy for research scientists cannot be considered sound until every vestige of pseudo-objectivity, everything a clerk can put a finger on, is washed away, and until the responsibility rests squarely where it belongs, on the responsible scientists themselves. In my opinion, the only obstacles to accomplishing this are inappropriate precedents and inertia.

Purchasing Procedures

Another area where government administration is inappropriate to research is in purchasing. Government purchasing procedures are geared to the procurement of large quantities of material, whose need can be foreseen long ahead, so that speed is no object, for which very elaborate sets of specifications can be prepared, and for which price is a prime consideration. Research usually needs small quantities, often only one, of definite articles for which the cost of preparing specifications would far exceed the cost of the article, usually needs them quickly, and the cost is no consideration compared with the loss of time due to delay. We cannot expect first-rate research in government laboratories if it is continually frustrated by cumbersome and entirely inappropriate purchasing procedures. Moreover, we know that appropriate ones are possible because there are a few government laboratories where they are in effect.

Of course, the success of the big government laboratories depends on much more than just personnel and purchasing procedures. I couldn't begin to go into that whole question; but I will propose a touchstone. I will suggest that if any such laboratory can evolve a way of operating that really fosters fundamental physics, can find a way to wall it off and protect it from the day-to-day demands of development programs and yet at the same time to keep the contact close enough to provide a stimulus; to value it for its own sake and support it for its long-range influence; and if this laboratory is actually successful in producing significant fundamental physics, then it will inevitably also be successful in whatever programmatic tasks are its reason for being. It is no accident that the two industrial laboratories which have produced Nobel prize-winners, the Bell Telephone Laboratory and the General Electric Research Laboratory, are also two of the most successful in the country by strictly practical criteria.

If basic research is to be justified in the government laboratories, it must be genuine. It must be the privilege of genuine physicists who have already demonstrated their capacity for research. When young men are allowed to share in this privilege, it must be as disciples of proven physicists until they too have, by actual accomplishment, shown that they can produce on their own. There could be no quicker way to give basic research in government laboratories a black eye, than to loose into it a number of young men, overimpressed by its glamor and undertrained and unproven, to putter with the trivial, or the already known, or the impossible, and to turn out reports of no greater significance than the ordinary bachelor's thesis. The conduct of basic research must be responsible; it must be under the responsible direction of proven scientists, or it may become a fraud and a pretense.

THE SUPPORT OF BASIC PHYSICS

If, as I have said, the industrial laboratories are growing and multiplying and basic science is beginning to thrive there; and if the great military laboratories are growing and multiplying and if there is hope for the growth of basic physics there; and if the AEC laboratories are well established and already producing some good basic physics; and if basic physics is also booming in the universities, as it is, what am I worried about? What justification do I have for asserting that there is a major crisis ahead in the support of basic physics?

For one thing, we cannot afford to rely on industrial or military or AEC laboratories for the continued existence of basic science, because that is not their primary reason for being; because science is not the master there.

It has yet to be shown that the atmosphere and the motivation in these institutions can ever be ideal for the conduct of pure science; though they may well devote considerably greater attention to it, to their own benefit. In general, their relation to it has been parasitic. They have made use of it, but have felt little responsibility for its progress. Science will be in a bad way if it has to rely on the mere hope that these agencies will provide a home for it, until their will and ability to do so has been proven.

SUPPORT OF RESEARCH IN UNIVERSITIES

Basic physics, in America and elsewhere, has been almost wholly the product of the universities, and there is not yet any assurance that it can really thrive anywhere else.

Unfortunately, there is no automatic assurance that it is going to continue to thrive in the universities. If it hadn't been for the far-sighted and prompt formation of the Office of Naval Research and for the very enlightened way in which its support has been administered, the universities would be in a bad way right now. All this depended on the boldness and insight of a few men in key positions, which is to say, it was partly accidental.

Right now, basic physics in the universities is flourishing. But it is vulnerable and in danger and something like a real crisis may not be far off. The endowed universities are in serious financial difficulties which are such intrinsic consequences of the general economic situation and tax structure that they are probably irremediable; and there is a strong move afoot to accentuate these difficulties by taxing their property. Moreover, the contributions of industry toward the support, in universities, of the basic science on which industry depends, are as yet relatively trivial. It is yet to be seen whether the state universities, whose financial future looks more promising, can really sustain a liberal and far-sighted policy without the leadership and competition of the endowed universities. At the same time the problems which seem to be crucial for physics at this time require large and costly machines and instrumentation, so that the progress of basic physics is more dependent on money than ever before. Somehow, we seem to find ourselves at the mercy of mammon.

Moreover, some of the government support of research in the universities (not that by the Navy) has tended to change the character of university laboratories somewhat toward that of government laboratories. Time-keeping, usually in an attenuated form, has been introduced, and, in consequence, clock-watching is not unknown. Government auditors are about. Property accountability and cost accounting have raised their ugly heads. Some universities have accepted classified projects and involved themselves with security. Reports are written—monthly reports, quarterly reports, progress reports, and final reports, and are dittoed, hectographed, mimeographed, and lithographed, and distributed to mailing lists. Forms are filled out, etc. Three secretaries blossom where one did before.

All this is superficial. The general tenor of physics in universities is pretty much what it has been except for the merging of individuals into teams, which is a consequence of the large scale of many experiments.

But it is by no means certain that the future of government-sponsored research in the universities will be so rosy. Federal budgets are getting tighter and there is a continual pressure from government financial offices for closer financial control and from some scientific offices for project control. It is usually called "seeing that we really get our money's worth," which is an unimpeachable motive; but it can be applied so that it has the effect of giving the government, for its money, the minimum of the original research that it really wants.

It cannot be too strongly emphasized or too often repeated that real fundamental research cannot be controlled or directed from any greater distance than the human voice can carry without the aid of a telephone. Any attempt to do so from any central office, however wisely, however brilliantly, that office may be staffed, is certain to have the effect of suppressing the more original ideas, which at the time of their inception are tender shoots all too vulnerable to unsympathetic criticism; and of emphasizing the sure things, the comparatively obvious, the predictable. Try taking any of the great ideas that have been turning points in the history of physics and imagining how it could, while it was new and original, have been written up as a proposal for government support!

On the other hand, published research can be evaluated with some accuracy from anywhere in the world, and we all do it all the time, and in the process evaluate the physicists who performed it.

For this reason government sponsorship of fundamental science, in contrast to its support of development programs, has to be in terms of men and not of projects; in terms of accomplishments and not of claims.

FEDERAL SUPPORT OF UNIVERSITY RESEARCH

For the most serious and immediate threat to the progress of basic physics in this country is that of reduction in the program of federal support of fundamental research in the universities. This program is largely carried by the Office of Naval Research and the AEC, and its emphasis is largely on the problems that physicists themselves consider most promising at the present time, especially on nuclear physics and the elementary particles. The effect of this program has been at least as beneficial for fundamental physics as the initiation of the National Research Council fellowships was in the twenties. It really saved science from the catastrophe that might otherwise have occurred after the war. It deserves the credit for keeping physics going strong in the universities for the last four years. The country is already reaping the benefits in the large crop of well-trained Ph.D's in physics which is now coming out and filling the gaps caused by the in-

terruption of education during the war. Many of the graduates are men who have been enabled to superimpose a sound and thorough fundamental training on a quite responsible wartime experience.

A most important effect has been to keep the more experienced physicists in the universities, by providing facilities which make first-rate fundamental research possible there. This has been fine for basic physics and it has been fine for the production of a new crop of physicists; but the other side of the picture is that it has made it more difficult for the government laboratories to attract staffs of the quality they need; to get back some members of their old first teams. And don't think they haven't been aware of it. Don't think that those in control of government science have failed for a moment to realize that one turn of the valve that controls the funds for basic research in the universities could divert a considerable amount of scientific strength into the military and the AEC laboratories. And they deserve a lot of credit for farsightedness and for courage for not having done it. No doubt the country and the government laboratories will be better off in the long run for their having stuck to this policy. No doubt the supply of young physicists who are coming out will be the first team before we are aware of it. No doubt the old first team will be the has-beens before they are aware of it. This chasing around after the same few dozen physicists can't last forever. Indeed, there are already signs that some of the big AEC laboratories are beginning to consider themselves the first team.

However, the temptation to turn that valve, to drain off the support of basic science in the universities, is stronger than ever, and the reasons are plausible. There is a reduction in military budgets at the same time that the deterioration of our relations with the Soviet Union and the Soviet Union's possession of an atomic bomb makes scientific military preparedness more and more essential, and this has to come early to be valuable. There are still far from enough good physicists in the military laboratories.

It is not easy to make generals and admirals, who are faced with the most urgent needs for the solutions of all sorts of development problems, realize that the wisest and most farsighted course is to keep basic science going full scale; that it will pay off in the long run with unexpected discoveries and in the production of scientists who will be available for new problems. To them it may seem like fiddling while Rome burns. It is not easy for statesmen and budget officials, who are desperately trying to reduce the federal budget to somewhere near the capacity of the country to pay, to realize that rather considerable expenditures in support of basic science are an absolute necessity if this country is, in the long run, to be able to defend itself in the next war, which will be a technological one. It behooves us physicists, who do understand this, to keep this point in the forefront of our minds through all the changes and all the confusion and all the exigencies of the developmental programs for which we are responsible; and to use our influence, which collectively is considerable, to see that the point is continuously and repeatedly urged home, so that it cannot be forgotten.

It also behooves us to keep our eyes open for the first symptoms of any tendency to diminish the support of basic science in the universities, or in the government laboratories, and to be alert for the first signs of faltering or indecision in our own ranks.

For one may be quite sure that this reduction won't come suddenly or as a major decision publicly discussed and openly arrived at. That would create a furor. That would be bad for public relations. No, if it comes about, it will begin gradually and subtly and inconspicuously. It will be impossible to find out who did it. It will be attributed to ogres, to mythical personages whom no physicist, at least, ever sees.

THE ROLE OF THE NATIONAL SCIENCE FOUNDATION

It will be stated, it has already been stated, that support of basic physics in the universities by the military, and by the all-but-completely-military AEC, is all very well as an interim measure but that the appropriate ultimate agency will be the Science Foundation. This is misleading. This is a red herring.

I'm strong for the Science Foundation. I think it should have been established right after the war. I regret the petty wrangling about details which has postponed it. And I sincerely hope it will be established at this session of Congress.

If it is wisely administered, it can fill a very important long-range need. But it would be fatuous to believe that it will take an important fraction of the load now taken by the joint ONR-AEC program.

The scale contemplated is too small, the support will be diffused over all sciences, it will to a considerable extent be distributed geographically. One of its major purposes, and a good one, is to make science flourish where it hasn't flourished before. This is fine. But it is even more urgent and more important that it be kept flourishing where it now is and in the fields where it is being most productive.

If we want scientific results, we must go where science already thrives, to institutions which have demonstrated their sincerity by making the financial sacrifices necessary to support it, and whose administrations have acquired an understanding of its subtle necessities; where buildings and equipment and tradition exist and above all where first-rate scientists are available and at home.

One major purpose of the Science Foundation is to develop science in geographical regions and in fields where it has been neglected. It is missionary work for the heathen.

The ONR-AEC program is for the already converted. Its offerings go to the temples where the priests are numerous and devout and where science can be worshipped properly.

The two are not the same thing.

BASIC PHYSICS THE ONE MASTER

To a physicist the one master can only be real physics; the search for understanding of the world. Whoever has a part in this, however small; whoever uses the methods of physics (instrumentation and measurement and logical thought made powerful by mathematics) for the purpose of increasing understanding, in whatever field, whether in nuclear physics or in biophysics or in, say, the peculiar properties of rubber, is a physicist; a title made glorious by much of the deepest and subtlest and clearest understanding that man has ever achieved.

He may do this by collecting data for future synthesis, by inventing instruments for others to make discoveries with; he may do it by teaching. He may earn his living in a patent office as did Einstein or by running a large milk business as did Lord Rayleigh or perhaps by improving television sets. So long as real physics is his chief loyalty, so long as physics is his master, he is a physicist.

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INTERNATIONAL COOPERATION IN SCIENCE: THE WORK OF UNESCO

Frank J. Malina

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READERS of the *Bulletin* have had an opportunity to consider the program of the Natural Sciences in Unesco on two occasions. In 1947 W. Albert Noyes, Jr. gave a report on the First Session of the Unesco General Conference which, on the basis of work carried out by the Preparatory Commission of the Organization in London, drafted a broad program for possible implementation.[1] This program was a catalogue of items which scientists thought would most effectively contribute to the international relations of science and to international peace and security. The great majority of the items belonged to classes of activities which were supported by some international experience before Unesco came into being.

In 1948 Bart J. Bok reviewed the results achieved by Unesco during the first two years of work.[2] It will be found that the general program of the Natural Sciences was carried out along the lines laid down in 1946. The 1950 program approved by the Fourth Session of the General Conference in Paris in October 1949 shows no major change in direction,[3] and it appears from program preparations now under way for 1951 that the original concept of the work of Unesco in the Natural Sciences will be maintained.

The Natural Sciences program, as conceived in 1946, thus will be unaltered during the first five years of Unesco's life. This is not because there has been a lack of criticism from some quarters, especially from the non-scientific majority which has concerned itself with Unesco in the United States, but because, on the international level, the major objectives of the program have been strongly supported.

The major objectives are: first, to bring science to those member-states of the organization which are underdeveloped scientifically or tenuously in contact with the main centers of modern science and technology; and, second, to develop in the citizens of all countries a better understanding of the scientific attitude and method, and of the possible impact on their ways of life to be expected from achievements in science.

To achieve these objectives, the Department of Natural Sciences operates along five main lines: (1) Scientific Organizations, (2) International Research Centers, (3) Scientific Literature and Material, (4) Science Cooperation Offices, and (5) Teaching and Popularization of Science.

SCIENTIFIC ORGANIZATIONS AND INTERNATIONAL RESEARCH CENTERS

Before Unesco came into existence, scientists found that they needed international organizations through which they could facilitate the exchange of ideas and data.[4] This need became imperative toward the end of the nineteenth century because the number of scientific workers in the world had greatly increased, and the traditional dependence on individual correspondence became inadequate. The number of international groupings in the basic sciences and in the applied sciences of agriculture, engineering, and medicine has become quite large. The latest count is about three hundred. Unesco is publishing a directory of these organizations in 1950.

Two reasons can be given why Unesco devotes its energies and small budget to these organizations. First, the organizations have been mostly voluntary, non-governmental bodies with very limited financial backing. Second, the organizations were heavily Europo-centric. Unesco has earmarked approximately one-third of the Natural Sciences budget of $750,000 for these organizations, to assist them in bringing together scientists from all regions of the world to discuss recent developments in their fields of work, to permit them to publish the results of their congresses and symposia, and to facilitate the creation of new groups where they are needed.

Unesco is able through the network of scientific organizations to obtain advice from the most highly qualified leaders in science on problems that the staff of the secretariat of Unesco can cover in only a limited number of spheres. For example, the International Scientific Unions for Pure and Applied Physics, Geodesy and Geophysics, Theoretical and Applied Mechanics, Geography, and the Biological Sciences submitted to Unesco recommendations on the possible structure and program of an International Institute of the Arid Zone, a project which Unesco is studying upon the initiative of India. A project for the establishment of an International Computation Center is also being studied following a proposal put forward by the United States. Unesco's work on international re-

[1] W. Albert Noyes, Jr., "Unesco Holds First General Session in Paris," *Bulletin*, III (March, 1947), 92.

[2] Bart J. Bok, "Unesco and the Physical Sciences," *ibid*, IV (November, 1948), 343; "Report of the Director-General on the Activities of the Organization in 1949," Unesco Publication No. 429 (1949).

[3] "Records of the General Conference of Unesco, Fourth Session," Unesco Publication 511 (November, 1949).

[4] J. Needham, "Science and International Relations," (Fiftieth Robert Boyle Lecture), *Blackwell Scientific Publications* (Oxford, 1949).

search centers is closely coordinated with the U.N. project for the establishment of United Nations Research Laboratories.

DO INDIVIDUAL GRANTS PRODUCE SIGNIFICANT RESULTS?

If at present there are about three hundred non-governmental and semi-governmental organizations which can request a part of the $250,000 Unesco uses for grants-in-aid and contracts, the amounts granted to any organization will be relatively small. Nevertheless, during the past three years it has been found that the amounts allocated for grants are in most cases assuring active international scientific collaboration and exchange of information, whereas, without the assistance of Unesco, the international bodies would be much more limited in scope and geographical reach. Unesco awards grants each year for projects proposed by some of the scientific organizations if they are of special international significance. In most cases, Unesco adds just enough to the funds an organization already has, to permit its project to be accomplished. For example, the International Union of Biological Sciences wanted to publish the proceedings of the Fourth International Congress for Microbiology and needed $1,000. Without Unesco financial assistance, the publication of the proceedings would have been long delayed, if carried out at all.

HOW DOES MICROBIOLOGY CONTRIBUTE TO PEACE?

The basic and applied sciences form a structure of knowledge of the universe. The structure is closely interlocked, and it is constantly undergoing repairs which are necessary to account for new discoveries and better interpretations of observed data. Just as it is difficult to draw a line between the basic and applied sciences, there is also a difficulty in setting up a system of priorities on the relative importance between the various branches and sub-branches of science into which man has divided his scientific labor. Subjects strange to the layman frequently lead to developments of vital importance to human welfare. If the improvement of human welfare is accepted as a contribution to peace and security, then a subject like microbiology deserves support from Unesco.

If Unesco must support only those activities that will *directly* contribute to the prevention of a Third World War, then most of the projects of the Natural Sciences would have to be jettisoned. No one has come forward with an alternate coherent program for the Natural Sciences in Unesco which would meet such a demand.[5]

DOES UNESCO PLAN TO EXPAND ITS GRANTS-IN-AID PROGRAM?

If the number of international scientific organizations continues to increase, which can be expected, especially in the fields of the applied sciences, then Unesco will be able to continue its present minimum program of financial assistance only if the funds available for this program also increase. The budget of Unesco for 1950 is $8,000,000 of which $756,000 has been allocated for the Natural Sciences program.

Many member-states of Unesco carry out their own programs directed toward international scientific cooperation. Perhaps in time the countries will divert these funds to Unesco, so that the funds of the various states can be utilized with a maximum of international effectiveness.

DOES UNESCO WORK OVERLAP THAT OF OTHER U.N. ORGANIZATIONS?

Research results obtained in one branch of science may be of vital importance to workers in a very different branch. While the application of scientific knowledge must be carried out by many organizations, it is highly desirable that the knowledge itself should not be compartmentalized. The WHO and FAO primarily direct their efforts toward the practical application of the results of research, while Unesco is concerned with international cooperation in science, and the interchange of the results of basic and applied research. There is, of course, a possibility of duplication of activities by Unesco and these sister-organizations, and, therefore, procedures have been worked out for the coordination of work between them. Unesco and WHO jointly sponsored a project which led to the establishment of the Council for the Coordination of International Congresses of Medical Sciences. Unesco collaborated with the FAO in 1949 in maintaining the former Library of the International Institute of Agriculture in Rome, and assisted in calling a conference for the foundation, around the Library, of the David Lubin International Agricultural Center.

In the United States, scientific work is carried out by the various executive departments of the Government; however the need for a National Science Foundation for research in the basic and applied sciences has long been felt. Unesco, within the framework of its constitution and those of the United Nations family, can be conceived of as a similar body on an international level.

THE INTERNATIONAL INSTITUTE OF THE ARID ZONE

The international non-governmental organizations have given advice to Unesco on the possible program and structure of an International Institute of the Arid Zone. Since 1946 there has been considerable interest in the project for an International Institute of the Hylean Amazon. This institute has not yet begun its work. In 1948, at Iquitos, Peru, an international convention for the Institute was agreed upon by Bolivia, Brazil, Columbia, Ecuador, France, Italy, Netherlands, Peru, and Venezuela, all of which, except Italy, have territory in the Hylean Amazon region. Thus far Columbia, Ecuador, and France have ratified the convention. Five ratifications are required for the convention to come into force. Brazil, which proposed the establishment of the Institute through its delegates to the First Session of the Unesco General Conference in 1946, is now debating ratification of the convention in Parliament.

As is the case with many international conventions and treaties, a long period is frequently required to obtain the necessary number of ratifications from sovereign nations party to an agreement. An international scientific institute that is to have power to work in several countries would represent a considerable development in international cooperation. Unesco provided its good services in bringing together the interested countries, and looks forward to the Institute's beginning its work in the near future.

[5] Bart J. Bok, "Science and the Maintenance of Peace," *Science*, CIX (February 11, 1949), 131; Byron Dexter, "Yardstick for Unesco," *Quarterly of Foreign Affairs*, XXVIII (October, 1949), 56; and Charles S. Ascher, "Unesco Gathers Momentum," *Survey* (June, 1949), 312.

PROTECTION OF WILDLIFE

We have been asked: Is it true that Unesco is diverting a part of its limited financial means to the protection of birds and animals? This seems to some a dubious activity when so many are worried about the protection of human beings.

Persons in many countries concerned with the problem of human ecology, and with the natural heritage of man, banded together in 1948, with assistance from Unesco, into the International Union for the Protection of Nature (IUPN). The Union's constitution states that the Union shall promote and recommend national and international action in respect to:

> the preservation in all parts of the world of wild life and the natural environment, soils, water, forests, including the protection and preservation of areas, objects, and fauna and flora having scientific, historic, or aesthetic significance by appropriate legislation such as the establishment of national parks, nature reserves, and monuments and wild life refuges, with special regard to the preservation of species threatened with extinction.

The IUPN is thus the principal body within the network of organizations affiliated to Unesco through which international action, legislative and educational, can be taken on problems of conservation of renewable resources and protection of the world biotic community.

SCIENTIFIC LITERATURE AND MATERIAL

The principal link in the chain of communication between workers in science is printed scientific information. At the present time it is estimated that in the member-states of Unesco there are approximately one million persons working in the basic and applied sciences, and that the results of their work are made available yearly in about one million separate papers which appear in about twenty-five thousand journals. The number of persons working in science and the number of reports is increasing in geometric progression, and the time delay between the completion of a piece of work and the availability of the information to a person working in the same or related field is also increasing. A scientist may have to wait many months before a paper published in another part of the world is available in a language he can read. The problem is very complex, and several international conferences have been held to study the problem.[6]

Unesco's main effort at the present time is directed to the problem of abstracting. Unesco, jointly with the WHO, assisted the formation of the Coordinating Committee on the Abstracting and Indexing of Medical and Biological Sciences, and in 1950 similar international committees are planned for Physics and Engineering, Pure and Applied Chemistry, and Agriculture and Applied Biology.

These committees deal with problems raised, on the one hand, by the abstracting, classification, and indexing of scientific literature, and, on the other hand, by the coordination of abstracting publications in various countries.

It is still too early to be able to evaluate the results of these efforts. The main obstacles to the improvement of the present international situation in abstracting are, first, the existing national systems which, although they may duplicate services in another country without complementing them, are going concerns; and, second, the lack of financial means for suitable services, especially for the principal languages in underdeveloped countries. When the United Nations technical assistance program for underdeveloped countries begins operation, Unesco plans to give financial assistance for the establishment of publication and abstracting services in some of these countries. Unesco has already contributed to the increased flow of scientific literature to soft-currency countries by introducing the Unesco Book Coupon Scheme which Unesco backs with hard currency.

WILL UNESCO PROMOTE A UNIVERSAL LANGUAGE?

Unesco decided not to promote the introduction of a universal language after considerable study of the problem. To help overcome the barrier of language to the circulation of scientific information, Unesco is assisting international organizations to publish interlingual dictionaries, and it will operate a center of technical and scientific terminology, with a view to collecting, classifying, and publishing information about new terms and the new meanings to be attached to old terms.

[6] *The Royal Society Scientific Information Conference; Reports and Papers* (London: The Royal Society, 1948); and "Final Act of the International Conference on Science Abstracting," Doc. UNESCO/NS/SAC/27, 1 August 1949.

INFORMATION SERVICE ON SCIENTIFIC EQUIPMENT

The information service on scientific *materiel* has been operating since 1947. Although this service was originally required in connection with the purchase of scientific apparatus for war-devastated countries, it has proved a valuable asset for assistance to underdeveloped countries. Studies are being made of the feasibility of extending the Unesco Book Coupon Scheme to the purchase of scientific *materiel* in hard-currency countries by scientists in soft-currency countries. These efforts are a part of Unesco's over-all program to remove obstacles to the free flow of publications and *materiel* of an educational, scientific, and cultural character.

To assist countries in equipping schools, Unesco is publishing Inventories of Equipment for the Teaching of Science. Inventories will be provided for primary, secondary, and vocational schools and for universities and technical colleges.

SCIENCE COOPERATION OFFICES

To strengthen the chain of communication between the centers of science and technology and the underdeveloped regions of the world, Unesco has established Science Cooperation Offices in Cairo for the Middle East, with a branch in Istanbul; in Shanghai for East Asia, with a branch in Manila; in Delhi for South Asia; and in Montevideo for Latin America.[7] Each office is staffed by two officers appointed from countries outside the region they serve. A locally recruited staff is also available to assist with the administration of the offices and with the technical services.

The offices have been established:

a) to organize the exchange of scientific information, personnel and *materiel*;

b) to promote discussion on scientific problems of practical regional importance;

c) to collect and disseminate knowledge of the problems and achievements of the scientists in their areas;

d) to collaborate closely with the field officers of the other specialized agencies working in their areas.

The headquarters unit in Unesco House in Paris acts as the service center for each of the offices.

[7] "Science Liaison," Unesco Publication No. 361 (1949).

COOPERATION WITH SCIENTIFIC ATTACHES

A small number of countries have begun to facilitate the *bilateral* exchange of scientific information by providing scientific attachés. Unesco, as an international organization, is able to facilitate *multilateral* exchange. Unesco cooperates closely with scientific attachés in those countries which have them.

STAFF PROBLEM

The staffing of the offices is gradually being enlarged. Even with the small staff that has been available during the past three years, effective work has been done, as the beneficiary countries have indicated whenever the project has been reviewed.

Technical advice is given immediately wherever possible, but when this is not possible, the officers write directly to sources of information outside the region or pass on the question to the Headquarters Unit which obtains the information. The international scientific organizations are a primary source of assistance to Unesco in this work, and this is one of the main reasons for the grant-in-aid program and Unesco's efforts to stimulate the formation of new international groups in scientific fields where they are needed.

The effectiveness of the offices depends on their collaboration with the Secretariat in Paris, and through it with the international scientific organizations.

LANGUAGE DIFFICULTIES

The working languages of Unesco are French and English. The scientists in the regions served by Unesco usually speak one of these languages. If possible, scientific officers for the particular region are selected who have command of the principal language of the region; for example, Arabic in the Middle East, and Spanish in Latin America. The locally recruited staffs in each region provide a direct cultural and language link with the local scientists and institutions.

CONTACT WITH SCIENTISTS OUTSIDE REGIONS SERVED BY OFFICES

Unesco maintains contact with scientists in Europe, North America, and other countries not served by Science Cooperation Offices mainly through Unesco National Commissions and through international nongovernmental organizations. It is recognized that at present only a small fraction of working scientists in these countries are acquainted with the efforts of Unesco.

If the general purposes of Unesco are to be achieved, it is essential that as many persons as possible working in the natural sciences become active participants in forwarding its program. The majority of the scientists working in the universities, in research laboratories, and in industry, who do not participate in international scientific activities, are generally unaware of Unesco. Since these persons are in direct contact with youth, and are influential in their communities, ways are being studied of enlisting them in national activities which are initiated by Unesco through National Commissions. Consideration is being given to the possibility of stimulating the formation of Unesco Science Faculty Clubs, which would assist Unesco projects, for example, by providing leaders for community groups which discuss the scientific subject of world importance selected annually by Unesco. In 1949 the theme was "Food and People," and in 1950 the theme will be "Energy in the Service of Mankind."

TEACHING AND POPULARIZATION OF SCIENCE

During the past three years Unesco has sponsored studies by the International Bureau of Education on the role and scope of science in primary and secondary schools. In 1949, on the basis of these studies, the International Bureau of Education published an *Introduction to Natural Sciences in Primary Schools*, and in 1950 a similar volume will be published on the teaching of science in secondary schools. These volumes contain a factual survey of teaching now being carried out in various countries.

There is a general feeling among scientists that there is much room for improvement in the teaching of science in general education. Unesco has therefore asked leading scientists to give their views on the place and role of their discipline in primary, secondary, and adult education, with special reference to the contribution which knowledge of their field can make in adapting man to the modern world.

DOES THE MODERN WORLD SUFFER FROM TOO MUCH SCIENCE?

One of the worries of the scientist is that he is being separated from his fellow-men because of his training, and is regarded either as a black magician or as a miracle man. The scientist, through the application of the scientific attitude and method, has enormously increased man's knowledge of the universe and his ability to control natural forces. Modern civilization largely rests on scientific developments of the past three centuries. Therefore, the scientist has the responsibility and frequently a missionary zeal to inform his fellow-men how and what he has been doing.

For the individual who is not a scientist, a knowledge of a vast number of scientific facts and technical formulae is far less important than an understanding of the meaning of science and of the influence it exerts on his living conditions and the progress of the world community.[8]

The problem of the impact of science on life is a serious one for all cultures. However, in underdeveloped countries, with the drive to improve the well-being of the people, there is a real danger that attempts will be made to impose technological developments before the people are in a position to participate in and to understand the implications of these developments.

Unesco is having prepared "Handbooks for the Teaching of Science in Underdeveloped Countries" to supplement the inventories of basic scientific equipment mentioned earlier.

Unesco is also trying to reach the peoples by stimulating the wider use of the various means for popularizing science, for example, through the press, radio, films, scientific exhibitions, etc. In 1948 the Lebanese Government was given assistance in setting up a science exhibition during the Third Session of the Unesco General Conference in Beirut. The exhibition illustrated the following topics: atomic energy in war and peace; history of language; numbers and writing; Arab contributions to science; and educational psychology. In 1950 a Latin American travelling exhibition dealing with astronomy, optics, atomic physics, aviation and science clubs will be opened in Montevideo.

[8] Watson Davis, "The Rise of Science Understanding," *Science*, CVIII, (September 3, 1948), 239.

DO SCIENTISTS COOPERATE IN POPULARIZATION OF SCIENCE?

Scientists, as a whole, believe that it would be highly desirable for everyone to have at least a general understanding of the scientific attitude and method and of the results of scientific work that are significant in daily life. Scientists are, at the same time, sensitive to the manner in which science is popularized, because of the tendency in the mass media to treat science in a sensational fashion. Some scientists have both the talent and the inclination to write about their work for the general public; for example Euler, in the eighteenth century, published one of the first popular books on science called *Letters to a German Princess*, but, on the whole, most of the effort of popularization rests with professionals in the various forms of mass communication.

The preparation of scientific information suitable for the press, radio, and films is inherently difficult, for the concepts or accomplishments of science are usually conveyed through the use of analogies with everyday experience, a process that easily leads to oversimplification or to a complete loss of the original meaning of the scientific concept.

Unesco is aware of these problems, and therefore is concerned with developing tools for popularizing science. These include associations for the advancement of science, science writers organizations, and science clubs.

THE PROBLEM OF DIVERGENT VIEWPOINTS

How does Unesco concretely tackle the problems of the interaction of science and society when there are so many possible viewpoints?

Unesco is an intergovernmental organization which carries out a program representing the majority will of its 50 member-countries. The countries vary greatly in their form of government, their standard of living, and their patterns of culture. Unesco therefore, limits itself to the statement of significant problems, and then obtains views on these problems from various qualified authorities in various parts of the world.

For example, to stimulate discussions on the theme "Food and People," Unesco commissioned leading persons to prepare pamphlets on topics ranging from "The Family's Food" by Margaret Mead of the USA, "The World's Larder" by S. Krolikowski of Poland, to "Population Problems of India" by S. Chandrasekhar of India. The selection of the topics and authors was made in consultation with the FAO and the Population Division of the United Nations.

As a part of the campaign in support of the Universal Declaration of Human Rights, several authors were asked to write pamphlets designed to present certain of these rights which particularly concern Unesco. One of these dealt with the Freedom of Science.[9]

The views expressed by the authors are their own. Unesco does not propose solutions of these complex problems, but encourages public awareness of them, especially from an international point of view.

* * *

I hope this article gives an indication of the interlocking character of the Natural Sciences program in Unesco, as well as a general view of some of the achievements and of the work in progress. As I pointed out, the objectives are to spread science more widely in the world, and to bring awareness to the general public of the attitude and methods of science and of the significant issues arising from new developments. A program with different objectives could no doubt be worked out, but so far no alternate coherent program of value to a majority of the member-states of Unesco has been proposed.

[9] Bart J. Bok, "Freedom of Science and the Universal Declaration of Human Rights," *Bulletin*, V (August-September, 1949), 211.

Bethe: The Hydrogen Bomb

(Continued from page 104)

much is at stake to miss any such opportunity.

On the other hand, President Truman has voiced the fears of many of us when he stated recently that there is no security in agreements with the Russians because they break them at will. He referred to the agreements of Yalta and Potsdam in 1945. Since then, we have learned much about Russian methods, and the Russians have found that we do not retreat as easily as they apparently imagined in 1945. This more realistic mutual appraisal makes it much more likely that we could now come to arrangements which neither side would regret afterwards. Obviously, in any negotiation, both sides have to be willing to make concessions, and to consider primarily the mutual advantage, rather than their superiority over the other.

The situation in atomic energy has changed through the Russian development of the A-bomb and through our decision on the H-bomb. To leave both of these uncontrolled would be against the best interests of both countries.

If we can seriously negotiate with the Russians, the scope should probably be as broad as possible. But the situation would already be eased if we could agree to eliminate the greatest menace to civilization, the hydrogen bomb.

Aron: The Atomic Bomb and Europe

(Continued from page 114)

will have completely forgotten its revolutionary origin, and when the pressure of the free world will have increased. Of course, this development will only be possible if no explosion occurs before the time is ripe for a change in the Soviet Union.

If such are the prospects, the free countries must strengthen their will to face a trial without precedent. It is important that we know why we resist and have no doubts about the legitimacy of our cause. And yet, Dr. Szilard considers it necessary in the interests of peace to trouble the good conscience of American public opinion. He uses, for this purpose, two arguments, one of which seems to me true, and the other false.

CAN AMERICA PROLONG THE COLD WAR WITH A GOOD CONSCIENCE?

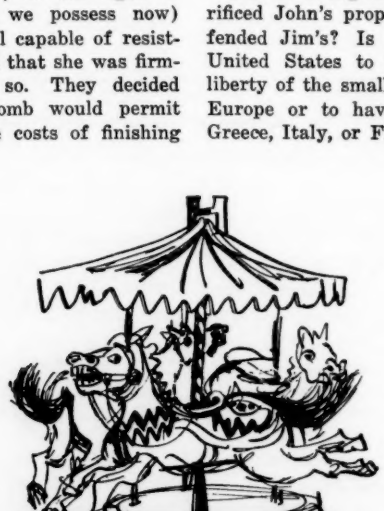
I willingly believe that the Soviet Union could not have accepted the plan for international control of atomic energy even if she had been a power like any other. She would have then

agreed never to acquire the know-how which her rival would have retained, despite the destruction of his bombs. The second argument is that the search for responsibility is difficult, that only Pharisees ask for the culprit, that the truth is the same as it was in the past in the wars between Sparta and Athens: The growth of American power menaces the Soviet Union, and the growth of Soviet power menaces the United States. Perhaps the historians of the future will report in these terms the drama through which we live, and this version may contain a grain of truth. Two aspirants to empire over a part of the world, or over the whole planet, would feel directly menaced, one by the other, even if neither has aggressive intentions. But this interpretation *au dessus de la melee* has no exclusive claim to truth. The judge who sends away both litigants is no closer to justice than the one who finds that one of them is right and the other wrong. In fact, since 1944, one of the two giants bears the main, if not the exclusive, responsibility for the tension, and this is the Soviet Union. Why? Because she has used her victory to impose upon 100 million Europeans a regime which the vast majority of them did not desire.

That the Americans, in the depths of their souls, have a sense of guilt, I can well understand. They have reason for it. They have dropped two atomic bombs on Japanese cities at a time when this terrible weapon was not needed to achieve victory, and a cheaper victory at that. This error is excusable: the military believed (erroneously, it seems, in the light of information which we possess now) that Japan was still capable of resisting for months, and that she was firmly resolved to do so. They decided that the atomic bomb would permit them to reduce the costs of finishing the war. Now, American public opinion has doubts about the wisdom of this decision, and worries about the consequences of the way in which the atomic weapon was revealed to the world. The other cause for worry is the fate of Eastern Europe. In practice, the hundred million Europeans who were once promised liberation have been delivered to the Soviet Union. They were sacrificed during the hostilities, for very realistic reasons which could be justified as such—but also on the vague idea that Stalin would be "satisfied" with the sovietization of his satellites. In other words, like France and Great Britain before 1939, America has more or less confusedly attempted to buy peace at the cost of the freedom of small peoples. Frenchmen have no right to condemn such behavior. But, when an American tries to analyze the psychology of his nation, it must be a matter of serious concern if he charges them with error in what they have done well, and does not reproach them with the errors they have, in fact, committed.

Let us end by developing the story of the children told in Dr. Szilard's article. A boy, older than they, has come to visit them. Their father, attracted by the noise, opens the door and helps to stop the free-for-all. "What has happened?" he asks the elder of his boys, Peter. Peter answers, "Bill first took away little John's toys, and I let him have them for the sake of peace. But he wanted also to take Jim's things, and then the fight started."

Was it wrong of Peter to have sacrificed John's property or to have defended Jim's? Is it the fault of the United States to have sacrificed the liberty of the small peoples of Eastern Europe or to have defended that of Greece, Italy, or France?



Dr. Szilard's Reply to Lilienthal

(Continued from page 109)

"Whether or not America should develop hydrogen bombs has been under discussion by scientists, behind closed doors, ever since October of last year. Soon after the Atomic Energy Commission put the issue up to the White House, the news began to leak to the press. The scientists, not wishing to embarrass the Administration at a time when it had to arrive at a difficult decision, exercised great restraint and, with one single exception, no scientist made any comment until the President had made his announcement. This self-imposed silence might have been a mistake, but at least it serves to show that if some scientists speak up now, it is not for lack of restraint that they do so. The reason for speaking up now is rather this: neither the President nor the Atomic Energy Commission have explained to the American people what the decision to develop hydrogen bombs will involve, what the meaning of the "hydrogen bomb" is, or what the cost of the indispensable defense measures will be. Yet these are things the American people must know.

"I am inclined to agree with Mr. Lilienthal that no useful purpose is served by scaring people. I do not believe, for instance, that it would help people, who are looking for a hidden exit in a theater, to shout to them that the theater is on fire, and I would not be in favor of doing so. On the other hand, if the house is actually on fire, I am opposed to keeping it secret for fear of scaring some of the occupants.

"If it becomes possible to detonate practically unlimited quantities of heavy hydrogen, then it automatically becomes possible to release very large quantities of radioactive substances in the air, simply by incorporating into the hydrogen bombs natural elements which become radioactive when they absorb the neutrons that are liberated in the explosion of the hydrogen bomb. The temptation of so rigging hydrogen bombs will be all the greater the more difficult it is to deliver large hydrogen bombs to specific targets in enemy territory.

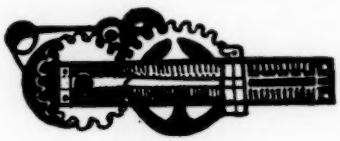
"It will not be easy to get across to the American people the possibilities and limitations of such radioactive warfare, but whatever we can say on the basis of published information, will have to be said.

"Mr. Lilienthal said that our con-

crete suggestions contained ideas that the Russians may not yet have thought of. This is difficult for me to believe, since we used only simple, straightforward reasoning, on the basis of published facts. And if the Russians have not gone through that reasoning by last Sunday, they surely will have gone through that reasoning by next Sunday. If the objections voiced by Mr. Lilienthal are valid, then Walter Lippmann should not be allowed to publish his column, for in trying to define what policy the Russians might pursue, he might give them ideas which they have not yet conceived.

"The President tells us that we are going to develop hydrogen bombs; the Secretary of State tells us that there is no possibility of an over-all settlement with Russia, and the cold war must go on indefinitely; and the Secretary of Defense tells us that he is looking to a reduction, rather than an increase, in our defense expenditures. These three statements taken together make no sense to me, and I doubt that they will make sense to the American people. What sense does it make to engage in an atomic arms race, and to step up its speed, without at the same time taking measures to protect the population of our cities? And how can we safeguard the population of our coastal cities against attacks by atomic bombs, except by relocating them?

"Mr. Lilienthal says that the people will never agree to being relocated, and therefore there is no sense in talking about relocation. It might very well be true that the people will decide against relocation and that Congress will not vote funds for it. But if that happens, and if the atomic arms race continues, and if the cold war goes on and on, there may be a price to pay. It is the people who will pay the price, and it must be their decision to pay it, and they will have to discuss it before they will be able to decide."



Loomis: Can Physics Serve Two Masters?

(Continued from page 120)

But if his primary concern is to make money, in the first place he is misguided because there are lots of other fields in which the same amount of ability will pay off better. And in the second place, he hasn't the religion. Whatever his ability, whatever his training, he has deserted to mammon. And he will come to hate physics. He will find the publications of physics repellent and the society of real physicists boring.

The problem before us is to assure the continued progress of basic physics. The difficulty is enhanced by the newly awakened realization on the part of the public, of industry, and of the military, of the practical importance of physics, and by their consequent demands for immediate practical results combined with their lack of understanding of the intrinsic needs and nature of the science which makes these results possible.

Physicists have a duty, of course, to make their knowledge and the power of their science contribute to industry and to our military potential. Doing so is often fun. It may call for abilities of the highest order. And there is no harm in enjoying the esteem that comes from practical accomplishment.

But the physicists themselves have got to keep in mind what is necessary if real physics is to progress, because nobody else is likely to. They have got to use their influence to see that the conditions under which it can thrive are satisfied and that it is given its adequate share of support despite the clamor for immediate "end" use.

In closing, let me anticipate the criticism that the views I have expressed are too idealistic and are unsuited to the military emergency of today. My reply to that is, that of all the courses the military situation can take, most of them utterly horrible, I can think of only one, the blitz war, beginning soon and ending quickly, in either victory or defeat, in which we could afford, from the strictly military point of view, to have neglected basic science. Hitler made that mistake. I'm not in favor of our repeating it.

AEC Predoctoral Fellowship Program

As a result of the loyalty investigations required of all AEC fellowship holders and the consequent reluctance of the National Research Council to administer the predoctoral program, the Commission has set up a new program to be administered on a regional basis. It will differ from the previous programs in that the subjects of research must be sufficiently closely related to atomic energy to justify the presumption that the candidate will be especially suited for employment by the Commission or one of its contractors.

Associated Universities, Inc., N.Y. will administer the program in the northeast, and the Oak Ridge Institute of Nuclear Studies, in the southeast. Argonne National Laboratory at Chicago and the University of California at Berkeley will handle administrative and financial matters connected with the program in the midwest and west. Supervision of the academic phase of the program, including the selection of fellows, will be handled in the midwest by the Midwest AEC Fellowship Board, established by the Board of Governors of the Argonne National Laboratory, and in the west by the Western AEC Fellowship Board, established by the University of California.

It is expected that 139 fellowships in the physical sciences and 105 in the biological sciences will be offered under the new predoctoral program. These will be in addition to the 250 fellows expected to participate in the NRC-administered program during the next academic year.

Correction

In Mr. Morgenthau's article which appeared in last month's issue one line was omitted from the bottom of the last column on page 77. The text at this point should read:

The issue, in the language of disarmament, was again security vs. equality. The monopoly of the atomic bomb gave the United States a military advantage over the Soviet Union which the United States was willing to give up only in return for adequate guarantees against any other nation's being able to produce atomic weapons.

NEWS IN BRIEF

● THREE-NATION COOPERATION. Representatives of Canada, Great Britain, and the U.S. met in February at Harwell to discuss revision of the Declassification Guides. A conference was held in March at Chalk River, Ontario, to discuss problems in radiation measurement.

The efforts toward wider cooperation between the Three Powers, which have proceeded intermittently since September 20, came to a halt in late February, as a result of the Fuchs case. According to the press, the British have agreed to continue the present arrangement under which Britain allows the United States to purchase nearly the entire output of the important Belgian Congo mines.

● DISARMAMENT.—In another proposal for world disarmament, Senator Tydings, chairman of the Senate Armed Services Committee, introduced a resolution requesting the United Nations to call a disarmament conference. His first proposal—that President Truman call such a conference—met with a strong popular response (The Senator reported receiving over 10,000 approving communications), but both President Truman and Prime Minister Attlee voiced disapproval of the proposal declaring that it would by-pass the United Nations.

Senator Brien McMahon's latest suggestion for waging peace is that a meeting of the United Nations be held in Moscow to work out a program of atomic control and world disarmament.

In a pre-election speech made at Edinburgh, Winston Churchill proposed a Big Three conference to discuss atomic disarmament.

● ROGGE'S PROPOSAL.—In a speech in Moscow, O. John Rogge, former Assistant U.S. Attorney General, suggested that a body be set up representing large and small nations within the U.N. which would have the right to unlimited inspection of all atomic energy installations everywhere in the world and also of all armed forces, armaments, and military bases.

● A BRITISH PROPOSAL.—The Executive Committee of the British Association of Scientific Workers has issued the following suggestions to serve as a basis for a fresh approach to the international control of atomic energy:

"1. National ownership, production, and distribution of fissile materials should continue, but there should be installed a permanent commission or inspectorate of the United Nations at every plant, the personnel of which should have access to all information necessary to record the production of all fissile materials and the use to which they are put. This inspectorate would be charged with the responsibility of reporting to the Atomic Energy Commission of the United Nations.

"2. Existing stocks of bombs should be dismantled under United Nations supervision within an agreed period after the signing of the Convention requiring the immediate establishment of the machinery of inspection suggested in the foregoing paragraph."[1]

● UNAEC.—Work at the United Nations Atomic Energy Commission is at a standstill. The secret talks of the Sponsoring Powers were discontinued on January 19, when the Soviet delegate left the meeting after the refusal of the Five Powers to accede to the Soviet demand that the Nationalist Chinese representative be ousted. There are no signs of any intentions to resume the talks.

● NEW AEC APPOINTMENTS.—Recent weeks have seen the following changes in personnel: the resignation of Commissioner Louis L. Strauss; the nomination of Thomas E. Murray, a director of the Chrysler Corporation and President of the Metropolitan Engineering Company of Brooklyn, to fill the vacancy created by David E. Lilienthal's resignation; the appointment of Commissioner Sumner Pike as Acting Chairman of the Commission; the appointment of Ganson Purcell as Head of the Personnel Security Review Board, succeeding Charles Fahy; of Lindsley H. Noble, as Controller of the AEC succeeding Paul M. Green; of John A. Derry, to the newly established post of Executive Officer of the Division of Biology and Medicine; of Dr. Charles L. Dunham as Chief of the Medical Branch, succeeding John Z. Bowers; and of Dr. Paul B. Pearson, as Chief of the Biology Branch.

● MILITARY MEMBER OF COMMISSION PROPOSED. — A congressional proposal, sponsored by Senator Millard E. Tydings and Representative Paul Kilday, requiring that the President appoint at least one military man to the Commission and making permissive the appointment of two such officers revived the old issue of civilian *vs.* military control of this body. The issue was referred to the Joint Committee, where McMahon, the chairman, immediately made his opposition known. At a press conference on March 9 President Truman expressed his disapproval of the Tydings-Kilday bill.

● APPROPRIATIONS.—In his annual budget message, President Truman requested $817,000,000 for the AEC in fiscal year 1951 for "production of fissionable materials and weapons and for the advancement of the science and technology of atomic energy." This amount exceeds the sum spent in the current fiscal year by $144,000,000.

The President included a provision of $500,000 for the initial administrative expenses of the proposed National Science Foundation designed to "stimulate basic research."

● NEW CHIEF FOR RESEARCH AND DEVELOPMENT BOARD.—President Truman has nominated William Webster, executive vice president of the New England Electric System of Boston, as chairman of the Research and Development Board. Mr. Webster succeeds Dr. Karl T. Compton, who resigned last November.

● CIVIL DEFENSE.—The National Security Resources Board has recently appointed Dr. Paul J. Larsen as Civilian Mobilization Director. Mr. Larsen is a former director of the Sandia Laboratory at Albuquerque, N.M.

A third report, *Damage from Atomic Explosion and Design of Protective Structures*, has been prepared for the NSRB by the Department of Defense and the Atomic Energy Commission. The report presents recommendations on the construction of buildings and bridges to resist or reduce the effects of atomic blast.

The Joint Congressional Committee on Atomic Energy opened secret hearings on civil defense on February 17. A month later public hearings began, with officers of the AEC as the first witnesses.

The Bulletin hopes to devote, in the near future, an issue to the problems of civil defense.

[1] *The Scientific Worker*, V (January 1950), 12.

THE BULLETIN HITS THE HEADLINES

Minneapolis Morning Tribune

Atom Experts Take H-Bomb Case to People

(Following is the first of six stories prepared by the American Society of Newspaper Editors' Committee on Atomic Information in collaboration with the Bulletin of the Atomic

(The articles digest the significa bomb issue" of the Bulletin for March scientists. They will summarize popu H-bomb and the question

[Distribute

A great number of They are worried about t soon be given to man in

They fear Americans have not been told what this and other new weapons can do to them . . . and that Americans are not deciding—and not even being given the means to decide—how to behave in a world that contains these new weapons.

The scientists fear that whether or not a hydrogen bomb can be built, the total of all modern weapons is affecting our nation's security so rapidly that congressmen and generals and the people are being left far behind.

Many fear that 1950 could be the eve of war, and that America is not properly using science to prevent or win it.

Three weeks ago a representative of the Bulletin of the Atomic Scientists visited a Midwestern editor, chairman of the Committee on Atomic Information of the American Society of Newspaper Editors, and a sheaf of magazine proofs of the still unpublished Bulletin.

SPONSORED BY A scien

LID OFF ON H-BOMB TALK

Weapon No 'Secret' To World Scientists

Scientists believe there is no hydrogen bomb secret, just as there was no atom bomb secret. Four years ago an Austrian physicist devoted a chapter to

(Distributed by International News Service)

bomb "secret," any more than of the atom.

HYDROGEN BOMB 'SECRET' IS MYTH

Austrian Scientist 'Told All' Way Back in '46

This is second of

'YES,' SAYS ATOMIC EXPERT

Science Needed Peace and War?

Note: This is the fourth of six articles on the H-bomb and the problems it raises for citizens of the United States. The articles were written by Victor Cohn, science writer for the Minneapolis Tribune, and were based largely on information in the March issue of the Bulletin of the Atomic Scientists. They were prepared in co-operation with the committee on atomic information of the American Society of Newspaper Editors and the Bulletin of the Atomic Scientists and are being distributed to all Amer-

Cohn

Detroit Free Press

CLEVELAND PLAIN DEALER

Courier-Journal

SUN

CHICAGO DAILY TIMES

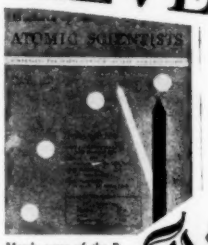
San Francisco Chronicle

THE CITY'S OWN PEOPLE-OWNED NEWSPAPER

Philadelphia Inquirer

PUBLIC LEDGER

DAILY OKLAHOMAN



March cover of the Bulletin of the Atomic Scientists, hands standing at 12. Illustration

SUN-TIMES writer Herman Kogan makes a dolorful discovery . . . we can't hide out in caves. See page 4.

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The scientists
fear that
whether or not
a hydrogen
bomb can be
built, the total of all modern
weapons is affecting our nation's
security so rapidly that congress-
men and generals and the people
are being left far behind.

DR. RABINOWITCH

LITTLE TO HIDE—

When it comes to the H-bomb basic scientific facts, the fact there are no facts to hide.

It is now common knowled that top scientists believe y can set off an explosion in so forms of hydrogen, using the plosion of an ordinary A-bo as the trigger.

Says Yes

entists today to help preserve our precious if need them to save us if an enemy should

ch professor of physics at the Uni- two questions this week in the mb issue—of the Bulletin of

questions is "yes." his colleagues, his of the most

Fre at the U Pennsylvania, chairmanship of Carnegie Tech.

During the war he w project, helping develop ato directed the Oak Ridge, Tenn., In

Seitz

T... Wa... Scientists

(EDITOR'S NOTE: This is the second of a series of five stories prepared by the American Society of Newspaper Editors' committee on atomic information in collaboration with the Bulletin of the atomic scientists. The articles digest the significant contents of the March 20 "Hydrogen Bomb Issue" of the Bulletin, published by top-ranking scientists in this country. The articles contain a summary of basic popular information about the H-bomb and of the questions of national policy arising from it.)

By The Associated

The H-Bomb—Deadly Foe of All?

Poisoning of Earth's Air Now Within Range, Say Scientists

...ag is a digest of another article from the March 20 ...b Issue" of the Bulletin of the Atomic Scientists. ... designed to provide a basis for intelligent ... national policy.

...he basic H-bomb theory, but cannot ...will work. Dr. Hans A. Bethe, one ...completing it will take "sev- ...shorter—the time may

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Distributed by Associated Pr...

A GREAT number of America's top scientists a... ...y are worried by the new means of destruction ... ...on be given to man in the hydrogen bomb.

They fear that Americans have not been told what ... ... and other new weapons can do to them . . . and that Americans are not ... ...decide—how to ... ...ydrogen bomb can ...cting our Nation's ...ls and the people ... and that America ...it.

...cation called The ...Midwestern editor, ...formation of the ...

The H-Bomb and You!

First of a series on the world's gravest problem starts on page 3

It is true, Albert ... that "radioactive

Dr. Pr... 12 physicists who have ... should build the

with Dr. Louis ... dean, writing in ...

American Society of Newspaper Edito...

Announcing...

MINUTES TO MIDNIGHT

The International Control of Atomic Energy

EARLY IN APRIL the Bulletin of the Atomic Scientists, in cooperation with the Social Science Staff of the College of the University of Chicago, will publish this 96-page book on the most crucial problem of our time: The International Control of Atomic Energy. Month by month, since its inception in 1945, the Bulletin has followed the attempt by the United Nations to find a way to secure the world against the threat of atomic warfare. It has published the important documents from the Truman-Attlee-King Declaration to the latest U.N. resolutions. It has carefully condensed the various plans for international control — the Acheson-Lilienthal Report, the Baruch Plan, the Soviet Proposals—summarized the reports of the United Nations Atomic Energy Commission, reported the debates with objectivity, and presented significant articles on the subject by leading scientists, statesmen, and political scientists. In MINUTES TO MIDNIGHT these documents and articles are gathered together in convenient form to give a complete, authoritative and unbiased account of the control negotiations. The Introduction and commentary is written by Dr. Eugene Rabinowitch, editor of the Bulletin. The material was selected by the Social Science Staff at the University of Chicago.

The purpose of MINUTES TO MIDNIGHT is to acquaint people with the actual course of the negotiations, with the large areas of agreement already reached, and with the true character of the disagreements which have obstructed this search for sanity.

The Deadlock Must Be Broken!
The Choice is: Control or Destruction

MINUTES TO MIDNIGHT will be of especial interest to Study Groups concerned with the Great Issues of our time; Leaders of Forums and Round Table Discussions; Club leaders; College and University classes in the Social Sciences, etc.

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Publication Date: April 15, 1950

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